SOUTH FLORIDA WATER MANAGEMENT MODEL

Agency Review of SFWMMv5.0 preliminary through RECOVER Model Development and Refinement Team

Review Comments and Response

June 13, 2003 DRAFT

Hydrologic Systems Modeling
South Florida Water Management District

Acknowledgements

SFWMM Model Development and Application Team

The South Florida Water Management Model has been developed and applied by staff of the Hydrologic Systems Modeling Division, Water Supply Department, South Florida Water Management District. Staff that have contributed towards the modeling effort and either directly or indirectly towards this response include Alaa Ali, Jenifer Barnes, Liz Bologna, Lehar Brion, Luis Cadavid, Hal Correa, Michelle Irizarry, Danielle Lyons, Pierre Massena, Angela Montoya, Raul Novoa, Jayantha Obeysekera, Winifred Said, Ray Santee Sharika Senarath, Ken Tarboton, Paul Trimble, Dave Welter, Randy VanZee, Cary White and Walter Wilcox. This response has been drafted and edited by Ken Tarboton.

Reviewers

Agency review was provided by the following individuals.

Gwen Burzycki (GB), Miami-Dade, DERM
Michael Choate and Samuel Lee (MC/SL), U.S. Army Corps of Engineers, Jacksonville District
Shawn Komlos (SK), U.S. Environmental Protection Agency
Callie McMunigal and Freddy James (CM/FJ), U.S. Fish and Wildlife Service
Sherry Mitchell-Bruker (SMB), Everglades National Park
Chandra Pathak (CP), South Florida Water Management District
Mike Waldon (MW), U.S. Fish and Wildlife Service
Carl Woehlcke (CW), South Florida Water Management District

Review comments in this response are attributed to individual reviewers by using their initials.

Introduction

An agency review of the SFWMM v5.0 was initiated by the Restoration Coordination and Verification (RECOVER) Model Refinement Team (MRT). The process is described in more detail below. It was requested that review comments be submitted under the following headings

Questions
Concerns
Model Limitations and Appropriate Use of the Model
Critical Recommendations
Non-Critical Recommendations

This response to the review is organized by first addressing "Critical Recommendations". Then "Questions and Concerns" are addressed by subject. Observations and recommendations regarding the model limitations and its appropriate use are included in the "Model limitations and Appropriate Use" section. Other comments, recommendations and suggestions are included in the section on "Non-Critical Recommendations". In these sections, comments and questions have been grouped by subject. In cases where questions or comments were similar or many questions were asked around the same topic, the question has been paraphrased or summarized. A final section entitled "Other Questions" is included to answer questions with brief responses, one word answers and unanswered questions.

When quoting a reviewer, the comment or question is *"italicized within quotations"* follwed by the initials of the reviewer(s). Paraphrased questions and responses are in normal text. All of the comments by the reviewers are included in their entirety in the appendices.

Review Process

The RECOVER Model Refinement Team initiated MRT/agency review of several models already in use in the Comprehensive Everglades Restoration Plan (CERP) or to be considered for use for CERP modeling. The review process laid out by the MRT involved presentation of the model to the MRT, a month for the MRT to provide technical review comments and then a month for the model developers to respond to the comments received.

The South Florida Water Management Model (SFWMM) was presented at the August 5 MRT workshops. RECOVER participants, agencies, tribes, and the public were encouraged to provide technical review comments on by September 6, 2002 to a MRT model liaison and to the model developers. All comments on the SFWMM were received by September 12, 2002.

The model developers asked for an extension of time address comments in order to enable re-calibration of the model prior to addressing comments. Re-calibration was necessary following changes as a result of some of the comments. Also during the review period significant problems were found in the database from which data was extracted for model calibration and verification. Considerable effort and time was needed to address and rectify the database issues prior to re-calibration and verification of the model.

The response by the SFWMM modelers, in this document, is to be presented to the MRT at a follow up meeting July 17, 2003). Following the discussion and response, reviewers will be asked to submit recommendations and the MRT model liaison who will compile these recommendations and draft a strawman MRT recommendation. The MRT will schedule a meeting to discuss and finalize the recommendations following which the MRT tri-chairs will provide written recommendations to RLG.

Critical Recommendations

Mass Balance

There are concerns that the model does not check for or calculate mass balance.

"Apparently there is no run-time global mass balance check on the model. This is of great concern,……. The non-iterative approach taken in this model is not likely to provide for a solution that achieves mass balance throughout the domain and could lead to highly unreliable predictions regarding the volumes of water that are provided for the estuaries and water supply. ……The model should be iterated until mass balance is achieved or a maximum number of iterations has been reached." SMB

"The model incorporates the complexities of the water management schemes but does not rigorously calculate the water balance." SMB

Great care is taken in the model to ensure global and local mass balance. Monthly and annual water budgets are produced for each part of the model domain. Part of model QA/QC before releasing a simulation involves checking to ensure mass balance in each sub-area. Residuals are reported.

Density-dependent effects at coast

Recommended that a density correction be implemented at coastal boundary.

"The model does not simulate density-dependent effects at coastal boundaries, which are known to be significant. By calculating an equivalent fresh-water head at the coastal boundary, the density-dependent effects can be approximated. This is a relatively simple modification and should be implemented in the near future." SMB

"Concern: Lack of saltwater density head impacts at the coastal boundaries. A density correction could easily be applied to tidal boundaries." MC/SL

"Concern: Recent information from SICS model development indicates that density transport functions are very important to critical for calibration in salt intruded areas. The SFWMM does not have this function, yet its output is being used to judge performance in coastal areas …" GB

A simple density dependent adjustment has now been implemented. An adjustment to the tidal boundary stages due to the difference in density between fresh and salt water is given by:

$$head_{adjusted} = 1.025*(head_{unadjusted} - CRP) + CRP$$

Where

$head_{adjusted}$ is the equivalent freshwater head (ft. NGVD)
$head_{unadjusted}$ is the elevation of saline water surface (ft. NGVD), and
CRP is a common reference point. A value of -2.0 ft was used as a CRP.

Ridge and Slough Land Cover or Land Use

"Ridge and Slough land use changes are based on an assumption that there is less resistance to flow in landscapes that have less directionality. This assumption is untested and is particularly unrealistic in northeast Shark River Slough (NESRS)." SMB

To the contrary, the model assumes less resistance to flow in Ridge and Slough landscapes that have been less impacted by anthropogenic activity and have maintained their directionality. The Ridge and Slough land use type is discussed further in the section on Land Use or Land Cover under Questions and Concerns and updated documentation on the final Land Use coverage for SFWMMv5.0 will shortly be available on the web at http://www.sfwmd.gov/org/pld/hsm/models/sfwmm/index.html

"The land use coverage document posted at the SFWMM website indicates that in Northeast Shark River Slough, the land use is specified as Ridge and Slough II, which is assumed to have less resistance to flow than other areas with less directionality." SMB

NESRS is now Ridge & Slough IV which gives it higher resistance to flow than Central Shark River Slough. The document referred to had suggested starting values for the calibration process. The final values will shortly be made available at http://www.sfwmd.gov/org/pld/hsm/models/sfwmm/index.html.

"It is inappropriate in this area [NESRS] *to assume that resistance to flow is less than in other areas. In fact, in the water conservation areas, where water tends to be deep, resistance to flow is most likely to be less than in the sawgrass-dominated sloughs where linear ridge and slough features are more evident."*

Resistance to flow is depth dependent and is expressed in terms of Manning's roughness "n" in, $n = Ah^b$, where Manning's resistance to flow, "n" is a function of parameters A, b and the depth of water h.

Model Development and Improvement

"A suitable tool is needed to support RET evaluations in the coastal areas. Either some means should be found for expanding the SFWMM model out into open water, or a companion tool (to be used in conjunction with the SFWMM) should be developed that provides reliable information on the model boundary. Hydrodynamic models, such as the Biscayne Bay hydrodynamic model, that simulate coastal physical scenarios could be used as companion tools to evaluate flows to the coastal regions" GB

Finer resolution models that include density dependent and hydrodynamic simulation cover the southern boundary of the SFWMM. These models include the USGS - SICS and TIME models. See http://sofia.usgs.gov/projects/sheet_flow/ for more on SICS and http://sofia.usgs.gov/projects/summary_sheets02/timesum.html for more on TIME.

"there should be a "line in the sand" where HSM is authorized to refuse to incorporate a feature because it is just too small. Alternatively, since the effort to create a new generation model with finer resolution is underway but will take time, it might make sense to somehow nest a finer scale model into these areas that would appropriately model such features and then feed output back to the larger scale model." GB

"We are concerned about the continuing trend for requesting that the SFWMM be able to model features that are really too small for the model to 'see'." GB

We agree. Small features are better handled with finer resolution models like the Regional Simulation Model (RSM, http://www.sfwmd.gov/org/pld/hsm/models/sfrsm/index.html). Within models under development the possibility of nesting and zooming has been considered. It may be used if appropriate.

Data

"Data on flows to the coast from project canals must be improved. This is a data collection issue that is critical to improving confidence in model output. …… a separate data collection effort is needed that will support appropriate improvements to this and other models used for CERP." GB

Data collection to improve models needs to be addressed in the RECOVER Monitoring and Assessment Plan.

Questions and Concerns

Calibration and Verification

Capturing extremes

"… calibration and verification for the major components should include both flows and stages The calibration and verification should attempt to capture the 'central tendency' as well as the 'extremes' of the important hydrologic characteristics at a landscape" CM/FJ

"Why does the calibration and verification for the Lower East Coast (LEC) generally miss the extremes, both high and low? How confidently can we evaluate conditions associated with extreme events as they relate to flood control and water supply?" CM/FJ

"it appears to me that the model may be least well calibrated during extremes, and fits best during more typical conditions. Calibration metrics should therefore be reported for both modeled versus observed performance measures" MW

The SFWMM has now been calibrated and verified using daily stage date rather than end of week stage data in the previous calibration. Attention has been paid in the recalibration process to capture the extremes. Calibration and verification is performed for periods that include a wide range of rainfall, stage and flows from available data with adequate quality for calibration. This minimizes the occurrence of hydraulic conditions outside the range for which the model was calibrated or verified. During calibration, model parameters are adjusted within a reasonable range. If significant deviations still occur, then other causes for the deviation are investigated such as perhaps the rainfall or ET distribution.

Calibration and verification graphics together with a table summarizing statistics of the calibration and verification are now available at http://www.sfwmd.gov/org/pld/hsm/models/sfwmm/index.html

Calibration metrics comparing modeled versus observed data using the indicator region performance measures are being developed for gauging locations within indicator regions. These may be available for the final presentation of this response.

"Calibration to gages in the urban LEC areas generally under predict the higher peak stages. Note calibration plots of gages PB732, PB831, F291 and S-196A. Since this appears to be systematic in the urban areas what do you perceive to be the problem and is it fixable?" MC/SL

This is not so much a problem as a limitation of scale of the model. Average stages over 4 square miles do not always capture extremes observed at point locations. An adjustment to the most recent calibration of SFWMMv5.0 has been made to better simulate higher stages by allowing more water to recharge the groundwater before entering the canal system during higher rainfall periods.

Calibration method

"Model calibration of the WMM (and ELM) involves imposing historic flows at all interior structures. This substantially limits the propagation of errors from one impounded area to downstream areas. …… This calibration approach works to minimize calibration errors and may inappropriately influence our estimate of model accuracy. How could this problem be quantified? Could structure flows be adjusted using structure rating curves and model stage error(s) such that when headwater stage is underestimated by the model the resulting structure flows would be reduced? How can this calibration error question be otherwise addressed? How can it be quantified?" MW

Historic flows are imposed in the calibration/verification method to

1) enable the adjustment of calibration parameters for evapotranspiration and resistance to flow while minimizing differences between calibrated and measured stage that occur due to differences between simulated and observed structural discharges,
2) capture the dynamic historical temporal variation in the operation of structures that would otherwise be impossible to reproduce.

Simulation of discharges is verified during the development of the model assumptions for the base condition (for which operations of structures are better known), following calibration of the basic hydraulic parameters (ET, flow resistance, canal – ground/surface water interaction)

"Surface flow data for the coastal water control structures is notoriously uncertain. This is resulting in problems with calibrating the model for discharges to tide. … there is no way to verify whether the model is providing realistic canal flows." GB

The model is calibrated against flow data for selected structures, at which sufficient data of adequate quality is available. Calibration statistics for canal flows can be viewed at http://www.sfwmd.gov/org/pld/hsm/models/sfwmm/index.html

"Since levee seepage represents a significant contribution to the overall water budget, wouldn't adjustment through calibration with verification of these coefficients on a continuing basis be desirable?" CM/FJ

There is adjustment of the levee seepage parameters through calibration and verification. This requires looking at gauged locations in close proximity to the levee and also at downstream discharges from the appropriate borrow canal if applicable.

Non-point flows

"Lack of ability to calibrate groundwater and surface water flow rates." MC/SL

The model is calibrated against selected structure flows (those with long enough record and adequate data quality). Measured data to calibration against groundwater flow and overland surface water flow are unavailable.

Calibration at specific locations

"Calibration and verification of 3B-SE hints that there is reason for concern particularly in light of the observed versus simulated S-335 HW stages. One might also expect concern with the flows as well." CM/FJ

Updated calibration and verification improves statistics for 3B-SE. For both calibration and verification periods, R^2 and efficiency are is higher while bias and RMSE are lower. See http://www.sfwmd.gov/org/pld/hsm/models/sfwmm/index.html.
Flows at S-335 calibrate and verify reasonably well. From the modelers' standpoint there is not reason for concern at this location.

"How are triggers for declaring water use restrictions and LEC phased cutbacks calibrated and verified? If the goal of "the calibration process is to mimic the duration and intensity of historical water restrictions" why isn't a discussion of the methodology with corresponding metric available in the ***calib_verif_plots_v50.pdf*** *or included in the 1999 SFWMM primer (SFWMM, 1999)? What documentation is available that shows the correlation between canal and SFWMM trigger well stages and the inland migration of the higher salinity levels that are presumably the basis for triggering water use restrictions?" CM/FJ*

The calibration of the triggers is performed to mimic the duration and intensity of historical water restrictions.

"What steps are taken in the calibration and verification to ensure that "history matching" occurs spatially and temporally between the occurrence of rainfall, stage and flows? It seems an important point to check that rainfall events occurring within a basin produce temporally correct levee seepage and canals flows with respect to magnitude and sequencing of stages? This is especially important on the boundaries between the WCA's/ENP and LEC." CM/FJ

Spatially distributed measured rainfall (from approximately 900 locations) is used as input to the model and stages at spatially distributed locations are compared with model simulated stages at the same locations. To ensure temporal matching historical (measured) data is compared against simulated data. Performance of the model spatially and temporally is based on statistics of comparison between historical data and simulated values. Where data for processes are not measured, such as levee seepage, checks are made to ensure that simulated values for these processes are within a reasonable range.

"Is it possible that the assumptions of EAA do have undesirable consequences with respect to the timing and volume of flows. How is this potentially compounded by the lack of calibration and verification data for the STA by-pass simulated flows? Could this data be passed to other regional or sub-regional models?" CM/FJ

In general, the evaluation of the SFWMM simulated flows for the EAA should be made in conjunction with an understanding of the model assumptions. The assumptions limit the way the simulated flows are to be interpreted (e.g. daily comparison is not recommended) but unintended

or "undesirable consequences" are unavoidable particularly when simulation alternatives or scenarios are markedly different from conditions that existed during the calibration period. STA by-pass simulated flows are small and very infrequent. They probably will not impact long-term trends as far as evaluation of alternatives is concerned.

"Why is the model insensitive to the coefficients that increase the amount of direct seepage from small reservoirs to the canal?" SMB

There is some self compensation in the model. The volume of water put into a cell with small reservoirs is constant. If the amount of direct levee seepage to a canal in an adjacent cell is increased the cell to adjacent canal seepage decreases and visa versa.

"predictive runs may change a parameter sufficiently that it now falls outside the range for which the model was calibrated. Has this ever been a problem, if so to what degree has it been a problem, and if this has the potential to be a significant problem, is there any way to compensate for it?" GB

It is possible that predictive simulations result in independent variables falling outside of the range for which dependent variables were calibrated. This has occurred when the stage difference across levees has fallen outside the range for which the levee seepage function was calibrated. This was not a significant problem as long as results are examined with an understanding of the overall combined effect and from a regional perspective. In the case of levee seepage, the large change in levee seepage for stage differences outside the calibration range was compensated for by equally large and opposite changes in groundwater flow. The model maintains mass balance. Intelligent interpretation is the best way to compensate.

"How will the updating be handled, and will it affect the scheduling for calibration runs, etc? Are periodic minor changes such as this clearly documented and at what point would it constitute an updated model version?" GB

The model will be updated as needed. Updates can include minor modifications to the model or even to correct and improve assumptions, such as errors in land use. If a change will effect the calibration of the model then it is not incorporated until sufficient new information is available to warrant a major update with an associated model recalibration. Typically major updates will only occur every several years at which time the period of record can be extended to use new available data. Any model code change will be associated with a change in version. Minor changes will be reflected in decimal version changes, e.g. v2.1 to v2.2 to v2.4. A major model change with an associated recalibration will result in an integer change in model version, e.g. from v2.x to v3.0. Major changes are documented by way of internal memorandum (often posted on the web). Minor changes are often documented by comments within the model code or input files.

Roughness Anisotropy

"Is there a directional component (e.g., depth-dependent anisotropic factor) to the roughness coefficients for the various land use types (e.g., type I ridge and slough versus type V ridge and

slough, predominantly north-south trending drainage canals versus predominantly east-west trending drainage canals, etc.)" SK

"The calibration could be improved by including an anisotropy term in the overland flow equations, which could have an important effect on flow directions in the SFWMM and the NSM model. However, before such a term is introduced, further analysis should be undertaken to provide a quantitative assessment of the ridge and slough effects. We would be pleased to work with the SFWMD to improve the SFWMM in this regard." SMB

A simple term that can differentially adjust the resistance to flow term in the x and y directions has been included in SFWMMv5.0. The sensitivity of using this term needs to be analyzed and tested. A sub-team within the Interagency Modeling center, including District, FWS and ENP staff has been invited to test anisotropy in the SFWMM.

Land Use

Miami-Dade

"There are very few citrus groves in Miami-Dade County, but there are plenty of other tropical fruit groves. I recommend that this land use type be generalized to "Groves" or "Fruit Groves" to improve the accuracy of this label." GB

Detailed agricultural land use was obtained through the Department of Agricultural and Consumer Services. This area was re-examined and several changes have been made. Citrus and other fruit groves are now classified as Fruit Groves.

"Cells labeled as 'shrubland' in southeastern Miami-Dade County …… are wetland areas
(R12 C31) should be either 'Mangroves' or 'Forested Wetlands'
(R11 C29, R10 C28) should be 'Forested Wetlands' " GB

After further review cells (R12 C31), (R11 C29) and (R10 C28) have been changed to 'Forested Wetlands'.

Pennsuco wetlands should be coded as "Sawgrass plains" rather than "wet prairie". I consulted with older, more detailed maps of the area, along with wetland biologists who have spent a great deal of time in the Pennsuco, and all of these sources confirm that the Pennsuco consists of a mixture of dense and sparse sawgrass alternating with open areas containing some pickerelweed, duck potato, and/or bladderwort. This area was originally part of the Shark River Slough and clearly has a much longer hydroperiod than the Bird Drive, as evidenced by the heavy sawgrass cover. It should be mapped accordingly." GB

Land use classification of the Pennsuco wetlands has been revisited. All areas that were historically a ridge and slough landscape have now been classified as Ridge and Slough with some degree of degradation represented by Ridge and Slough classes I to V. The ridge and slough landscape in the Pennsuco area has been degraded to the extent where the land cover is predominantly sawgrass as pointed out. Due to the degree of degradation of the original land cover, the Pennsuco area has been classified as Ridge and Slough V.

"The cell that was previously tracked to represent the Bird Drive Recharge Area (R21 C28) is now mapped as 'Medium Density Urban'. We need some clarification"

The predominant land cover in cell (R21 C28) is 'Medium Density Urban'. The SFWMM now has the ability to have a different land use in a cell that may have part of it designated as a reservoir. The actual cell that will be used when the Bird Drive Recharge Area is modeled may change to an adjacent cell.

Other Land Use Questions

"We are concerned about the use of the Welch et al. information for land use within ENP because we have repeatedly heard that there are errors in the mapping, although we do not have good information about either the extent or magnitude of the errors. Was the use of this source of information supported by ENP staff?" GB

It is the best available data to date. Model developers welcome documentation indication the reliability or non-reliability of data. Without such documentation the Welch et al. data is to our knowledge the best available data. ENP staff was not consulted on use of this data.

"… best professional judgment is always going to be present during the determination of representative majority land use for scaling up to the 2-by-2 mile grid cells from satellite and finer resolution land use maps. Are there plans to automate the classification of satellite imagery and detailed land use maps in the future for more quantitative assessment of errors or uncertainty introduced during this process?" CM/FJ

The Florida Land Use Code Classification System (FLUCCS) was relatively automated, however didn't classify land use according to hydrological characteristics. In the cross walk from FLUCCS codes to hydrological land use classification in the SFWMM automated majority land use types were used. There was also visual cross checking against satellite images and field verification.

Documentation

"The source code documentation is incomplete. There are hundreds of variables that are undefined. …… The documentation of the input data is generally good, although there are a few files with gaps in the documentation." SMB

Source code documentation can always be improved. As a first step towards better documentation comprehensive input file documentation has been undertaken and may be available on the internet in the future. All of the input variables are defined and documented.

"The material posted on the model website is not sufficient for a thorough model review. The map of the calibration targets shows many water level calibration points, however the plots and

the statistics for each of these points were not provided. The entire set of calibration plots and statistics should be posted with the review materials. The calibration input and output files should be posted with the review materials." SMB

A partial set of calibration plots was provided for the SFWMM v5.0 preliminary calibration. The entire set of calibration plots will be provided for the final calibration.

"*A calibration-verification report should accompany each major model release. This report should include a description of source code changes, input data set changes and a description of how coefficients and parameters were adjusted during calibration and verification. Plots of relevant calibration targets should be provided before and after parameter adjustment. In the event that changes in parameters and coefficients are made for the verification run, the departure of operations from the model operations should be demonstrated with data or written explanations." SMB*

A report will be produced documenting the SFWMM v5.0 final calibration and verification. It will include calibration and verification plots and tabulation of calibration and verification statistics. Model input, output and source code will be available for downloading via the internet.

"The documentation should be updated to include the new WSE schedule for Lake Okeechobee including adequate description of the algorithms used to simulate the decision tree." CM/FJ

There are two web sites available for WSE. These have graphics depicting the operational water levels and decision trees.
http://www.saj.usace.army.mil/h2o/lib/documents/WSE/
http://www.sfwmd.gov/org/pld/hsm/reg_app/lok_reg/index.html
Additional information can be found in USACE Water Control Plan for Lake Okeechobee and the Everglades Agricultural Area (2000)

Is model input self-documented? Do you follow procedures for model self-documentation (commenting)? Is there a prescribed style for commenting programs and procedures? MW

No, the model input is not self-documenting. However extensive input file documentation has been undertaken. Each input file is documented in a "man" page format. The entries are placed in the same order they are read by the respective subroutine(s). Description of each entry includes the variable names, "read" formats, and variable definitions. Electronic copies of the "man" pages of "all but one" input files are now available on District intranet (accessible by the Interagency Modeling Center) at http://iweb/iwebB501/wsd/hsm/models/sfwmm/man/index.html. The input documentation may be made available externally in the future if needed.

"More rigorous defense of the level of sophistication chosen to model each process would strengthen the documentation." CM/FJ

Quality Assurance

"Does the SFWMD have a model quality assurance plan?" MW.

No formal quality assurance plan is followed. Extensive quality checking of model runs is carried out before simulation results are published. Quality checks include checking for mass balance and checking that simulated results match conceptual understanding of expected responses.

"How was the model tested to locate programming or model structural errors in the code? For example, has the model been run for special cases such as constant parameters to determine if steady-state levels agree with analytical calculations? Is this testing documented? When new procedures are added to the program, what testing procedure is followed?" MW

"Does the model include tests (either internal or in a pre- or post-processor) that flag errors or provide warnings? For example, is it possible to cause the model to fail to conserve mass through errors in the input datasets, and would this failure be flagged? Are unusually high velocities or discharges flagged?" MW

Are there conditions under which the WMM model is unstable?

Since the algorithms for the hydrologic processes are explicit, checks are made in the overland flow algorithm such that flow does not cause reversal in head gradients between grid cells. Volume checks are made in structure discharge calculations such that canals or grid cells (depending on the origin of flow) are not overdrawn, assuring stability in surface components. An analysis was performed to determine the optimum time step for overland flow. For the 4 square mile a 6 hour time step was optimal. Instability in groundwater flow may occur when the grid resolution is too fine for the daily time step.

Do you maintain a list of known bugs?

Temporary lists are formed and once refinements are made the lists are discarded. Versions of the model are saved using source code control (sccs or cvs). Changes to the code can be traced by comparing different versions that have been put into source code control.

Period of Record

"How does the model period-of-record (POR) of 1965 to 2000 compare with the available longer POR (ie. NCDC 1895-2000)? An exhaustive statistical analysis is not requested. Instead, long term averages or running means would give general information about model period used to design system wide project features." MC/SL

There are variations of rainfall on several temporal scales. For some time we have been reporting that the 1965-1995 period was significantly drier than the thirty years period prior to 1965. The 21 years from 1970-1990 were particularly dry. On an annual average basis, this difference was about 10% which when accumulated over space and time becomes a very significant for issues

concerning water supply, minimal flows and levels, the number of large adverse impact flows to the estuary and hydroperiod.

Recently an extended period of rainfall record has become available beginning it's period of record in 1895. This period includes another drier period similar to the 1970-1990 period. In addition, the new five years added to the SFWMD simulation period have been wetter than average. Comparing the 1965-2000 period does not show a significant change in the means overall. However, within the 1895-2000 period there are several steps in the climate going back and forth between a wetter and drier rainfall regime that persist for several decades at a time. In addition, on shorter time scales (1-3years) the period between 1945-1964 appear to have a larger rainfall variability including larger dry and wet extremes when compared to earlier or later decades.

Global warming and sea level rise

"Given that the ET calculations have been converted to temperature-based formulae, to what extent will the influence of anticipated temperature differences be considered during the development of future-based alternatives/scenarios (e.g., according to the 2002 U.S. Climate Action Report, temperatures are projected to increase on the order of 0.6 ? 2.5 degrees centigrade by 2050)? Likewise, to what extent will the influence of those anticipated temperature differences be considered in the calculation of crop-irrigation demands? Given that the influence of sea-level rise (on surface water management) was simulated in scenarios of the 2050 baseline, and that sea-level rise is a response to temperature change, are ET sensitivity runs also anticipated? SK

Temperature changes and sea level rise will not be considered in the 2050 Base. It is anticipated that several sea level rise scenarios will be simulated following the initial Comprehensive Everglades Restoration Plan (CERP) update. The CERP Restoration, Coordination and Verification (RECOVER) Team is putting together the assumptions to be used in the sea level rise scenarios. These scenarios could possibly include temperature changes due to global warming and the resultant effects on ET.

Rainfall

"What rainfall value is considered threshold for extreme? (Extreme rain values are checked against nearest neighbors before accepting.) Given the patchy nature of wet season rainfall combined with the possibility for substantial rainfall from a single thunderhead, this threshold is very important in setting a filter for high rainfall events." GB

A map showing may of the rainfall stations can be found in the SFWMM v3.5 Primer at http://iweb/iwebB501/wsd/hsm/models/sfwmm/v3.5/wmmpdf.htm. This may be of some help.

Evapotranspiration

"Pre-processing irrigation and run-off demands seems counter intuitive with alternative testing of operational, structural, and feature modifications where depth of the water table is unknown previous to simulation runs. …… It is easy to visualize pre-processing the total net irrigation application depth, which is independent of the position of the water table but not ETU, evapotranspiration from the unsaturated zone. Isn't the depth to the water table a variable which is not known prior to simulation of an alternative?" CM/FJ

Pre-processing of irrigation demands in the Lower East Coast Area is a simplification due to the scale (much smaller than the model grid scale) at which different irrigation practices occur. Pre-processing allows for determination of irrigation requirements at a fine scale and aggregation of these demands to the model scale at run time. The depth to the water table is variable but for pre-processing in irrigated areas, it is assumed constant.

Supply Side Management

"How is the concept of "borrowing" in supply-side management applied to other consumptive water users? It seems difficult to reconcile the appropriateness of "borrowing" because of the appearance that the practice may create larger deficits later in the dry season. Such deficits would seem to be of concern as potentially they could be amplified with increasing severity of the drought, unknown at the time of the "borrowing". Since "borrowing" is used early in the dry season during periods of deficit rainfall what might the implications to other users be if the payback, due later in the dry season is not available? Is there a mechanism in the SFWMM to ensure that source water is not available to those no longer entitled while still delivering water to those who it is due? Are there any mechanisms in the model to assess the significance of "borrowing" with respect to inherent policy changes characteristic of drought events? How is "borrowing" calibrated and verified?" CM/FJ

The SFWMD supply-side management protocol (Hall 1991) outlines the concept of "borrowing" for use in the calculation of allocation to agricultural users of Lake Okeechobee water in the Lake Okeechobee Service Area. The SFWMM follows the procedures outlined in this protocol by "borrowing" during the first half of the dry season and paying back an equal amount during the second half of the dry season. Risk to other users is limited due to the fact that only 1/3 of future allocation may be borrowed. Additionally, since the supply-side management plan tries to reserve water for periods of high demand late in the dry season, the risk of unfulfilled payback is reduced. The SFWMM calibration/verification period makes use of measured flow data during the 1989 drought in which "borrowing" was practiced.

Uncertainty

"How has the information generated from the uncertainty workshop been integrated into an uncertainty and sensitivity analysis of the SFWMM inputs and performance measures developed to date for regional evaluations?" CM/FJ

It has not yet been incorporated or used in SFWMM performance measures.

Model Limitations and Appropriate Use

Appropriate application

"The model is primarily a planning model, which can be used to compare alternatives and predict trends in water distributions. …Because the model has been calibrated to match heads, it is most reliable in simulating heads under flow regimes that are not drastically different from the calibration flow regime. The calibration often requires adding adjustment factors that have no physical basis, but compensate for processes that are not explicitly represented in the model (for example, operator judgement). Therefore the model is most useful as a planning tool to compare scenarios that do not vary drastically from the calibration operations." SMB

"… the SFWMM is the only existing hydrologic model at the spatial extent of CERP, capable of simulating both the natural and managed hydrology of south Florida. This capability and the models ability to simulate the complex water management operational criteria associated with Central and South Florida Flood Control Project (C&SF) for flood control, water supply and environmental objectives has resulted in its previous and proposed application in a number state and federal water resource projects…" CM/FJ

"… more emphasis should be placed on spatial and temporal variations of climatic events and the range of operational strategies the model is capable of simulating and evaluating." CM/FJ

Scale

"The 2x2 mile cell size of the model is also a severe limitation. Subtle gradients in topography that have significant ecological implications cannot be represented in the model. … The scale limitations of the SFWMM also limit its use in flood impact assessments and structure design" SMB

"Spatial scale of cells and structured rectangular grid limit the model to a planning and water supply function, which it does very well. The model is appropriate to provide head boundaries to other models, but has limited ability to provide flow boundaries." MC/SL

"In the past the model has been used to predict changes in regional hydrology associated with changing the canal operational levels by tenths of a foot. Is the model capable of accurately distinguishing between these types of subtle operational changes?" CM/FJ

"Pre-processing irrigation and run-off demands seems counter intuitive with alternative testing of operational, structural, and feature modifications where depth of the water table is unknown previous to simulation runs. …… Isn't the depth to the water table a variable which is not known prior to simulation of an alternative? If it is, what simplifying assumptions are made to generate the spatial temporally variable water depth information used for ETU pre-processing at daily time step and land use mapping scale of 5, 20 and 50 acres?" CM/FJ

Integrated processing of irrigation demands is being built into the next generation RSM model. , (http://www.sfwmd.gov/org/pld/hsm/models/sfrsm/index.html).

Small Reservoirs

"reservoirs and impoundments that are narrower than the grid cell are modeled in a approximate manner, calculating the reservoir capacity and spreading the volume of water added across the cell. This small reservoir code requires further review and documentation. A finer scale model is required to adequately simulate small reservoir impacts and benefits." SMB

The small reservoir algorithms in the model have been revised so that the volume of water is no longer spread across the cell. A finer scale model would be more appropriate for simulation small features.

Non-Critical Recommendations

Performance measures

"Several CERP projects have recently completed development of their respective performance measures. This team needs to consult CERP project managers and obtain the performance measures and identify performance measures that are applicable and directly tie into the SFWMM model results" CP

The RECOVER Regional Evaluation Team (RET) has a process for vetting and approving performance measures for system wide evaluations. HSM staff works closely with the RET to take performance measures that have gone through their process and program and automation them for production from the SFWMM results.

"Some appropriate figures and tables could highlight where the model performs well, and where it does not perform so well. These figures should show which performance measures the model can reasonably simulate and which it cannot address at this time." CM/FJ

Flow gauging stations

" Several stations are used in the model calibration in each basin. The modelers need to identify the stations (used in the model) where stream gauging data are available from the District and/or from USGS. At these identified stations, the performance of the model need to evaluated and improved, if necessary, during the calibration phase." CP

Available flow data that have undergone QA/QC are used in the model during calibration. At several flow stations model simulated data are compared with measured flow data and model performance statistics reported. The extent of the evaluation is limited by the amount and quality of measured flow data.

"the modelers should identify and rank limited number (say 10 to 15) of additional stations where stream gauging data would be useful in improving the performance of the calibrated model based on modeler's experience. Then, the team should forward these identified stations (for stream gauging) to the appropriate agency (District or USGS)" CP

Good suggestion for Monitoring and Assessment Plan.

Rainfall

"The SFWMM model results are sensitive to the rainfall data. Specifically, spatial variations in the rainfall data are very important for modeling purpose. We have NEXRAD data available to us from 1996 to 2000. For further analysis, the calibrated model should replace the point-rainfall data with NEXRAD dataset. Then, the revised model should be fine-tuned (from 1996 to

2000) and compared with the results of the previous model (which used the point-rainfall data) for the same period-of-record. This process is expected to improve the performance of the calibrated model furthermore." CP

"There is always a need for better rainfall data in areas with highly patchy weather systems. Continuing support for improving methods to evaluate rainfall in this region.is recommended. The use of NEXRAD data should be explored as a possible solution." GB

Model assumptions

" Incorporate appropriate accounting for seepage water from reservoirs located north of Lake Okeechobee and for return flows due to irrigation withdrawals from Lake Okeechobee into the Lake Okeechobee Watershed. (Modeling of these basins as part of the LOW PIR may allow you to incorporate model results instead of having to make assumptions.)" CW

"Incorporate appropriate accounting for irrigation water delivered to the Big Cypress Seminole Reservation or adjust deliveries to meet supplemental ET needs rather than gross irrigation withdrawals." CW

Field-scale net irrigation demands for the Big Cypress Reservation are estimated based on an AFSIRS model which accounts for the contribution of rainfall to meeting ET needs and the application efficiency of the irrigation method. The estimated field-scale net irrigation demands are then transformed into basin-scale demands by accounting for local basin storage and basin efficiency, which includes losses to air and water conveyance losses. The final time series of supplemental demands from the regional system incorporates the S190 flow contribution to meeting a portion of the basin-scale demands.

"Consider adjusting the effect of utility pumpage on water budgets in the coastal basins. Utility withdrawals are not all lost to the system. Investigate the average and marginal ratios of wastewater disposal (deepwell and ocean outfalls) to utility pumpage. Be sure to explicitly include the effect of all expected wastewater reuse on the surface water/surficial aquifer water budgets." CW

"Be sure to incorporate the latest and best information regarding the effects of BMPs in the EAA on ET." CW

This has been done. Both the model verification (1991-2000) and 2000 Base now have BMP makeup water.

*"The Santee May 19, 1999 memo states, "**2050 BASE"**. Tailwater constraints due to stages at G3273 location for S-333 flows to NESRS have been refined as in the 95BASE. S-355 discharges are subject to stage constraints at G3273 gage location, as well as in L-29 borrow canal." For the 2050 Base one would assume that S-333 flows should not include the G-3273 constraints of 95Base, nor should the S-355. Completion of the Modified Water Deliveries Project is assumed in the 2050. It is possible that an L-29 constraint may exist in 2050 because of flooding concerns associated with Tamiami Trail road bed. However, it is believed that it is 9.0 ft rather*

than 7.5ft. The change in these criteria would be expected result in increased flows to Northeast Shark Slough via either S-333 or S-355, possibly warranting re-evaluation." ... CM/FJ

Noted. Assumptions for base simulations in the initial CERP update will be approved by the RECOVER Comprehensive Plan Refinement Team.

Calibration

"Since the calibration uses measured flows at the structures, there is no calibration process to assure that the equations used to simulate structure flows are adequate. Without this calibration, the value of the model as a predictive tool is limited. More effort needs to be made to calibrate the model flows. Discharge data at structures, flow velocities and discharges at coastal creeks and rivers are available and could be used for this purpose." SMB

"By presenting proposed changes in the topography to the MRT, the topographic data set was improved and our confidence in this new data set was increased. We encourage the SFWMD to use both the MRT and Inter-agency Modeling Center to continue this open review of the model updates." SMB

Assumptions about Lake Okeechobee's water surface and historical flows prohibits integration of calibration and verification of lake stages which seems counter-intuitive given that some quality control and assurance of the validity of the assumptions are necessary. CM/FJ

Documentation

" ... documentation should be updated to include recent revisions associated with each new version." CM/FJ

"A reference map with canal locations and gauges used in calibration and verification gauges would be extremely helpful." CM/FJ

These were posted on the internet at on August 13 at
http://iweb/iwebB501/wsd/hsm/models/sfwmm/v5.0/calib_verif_plots_v50.pdf

A reference map of rainfall gauges used for generating the daily rainfall binary files with reference table of period of records would be extremely helpful." CM/FJ

There is a map of rainfall stations used in SFWMMv3.5 available (p13) at http://www.sfwmd.gov/org/pld/hsm/models/sfwmm/v3.5/wmmpdf.htm. This may be of some help. A map showing the latest stations has not been produced yet.

"The ability to review the effects of changes of topography in the EAA and the central and Everglades on hydrology would be greatly enhanced by the inclusion flow calibration and verification graphics similar to those provided in the SFWMM V3.5 primer (SFWMM, 1999)

It would be helpful if a table of input parameter values was available that compared the degree of change between v3.5 and v5.0. This information could than be used to determine the degree of change for the new land use classifications from the initial values suggested in Table 2, page 19 of the June 5, 2002 memo 'Final Land Use Coverage for SFWMM 2000 Update.' " CM/FJ

This information will be posted to the internet following final calibration. See http://www.sfwmd.gov/org/pld/hsm/models/sfwmm/index.html

"A scan through of the document leaves many instances where the user of the model could come away without a clear indication its "strengths and weaknesses." Because of its wide use and application for many water resource projects, it might be helpful to codify the uses or applications in the form of performance metrics in an appendix as illustrative examples for reference." CM/FJ

"It would have been extremely helpful, albeit time consuming to have more of the literature cited, including the internal memorandums available." CM/FJ

Further review

"Because of the important role that the SFWMM has played and will continue to play in Everglades restoration efforts, it is essential that the model be thoroughly documented and reviewed. The model limitations must be identified and accepted and the uncertainty in the model output must be quantified. …Given the size and complexity of code, the many undocumented and undefined parameters and coefficients, and the heavy reliance on the model for Everglades restoration; Everglades National Park recommends an external detailed review of the SFWMM2000 application." SMB

"We recommend a more complete technical review of the SFWMM be initiated." CM/FJ

Complements

"Since the inception of the SFWMM in the 1970's the SFWMD has gone to great lengths in providing information about the model including source code, input and output, documentation, and calibration and verification data. In addition, they have initiated a series of training workshops to provide more in-depth and thorough explanations." CM/FJ

Other Questions

Short Answers

"During extreme high water events in Lake Okeechobee in the late 1990's, significant levee seepage and groundwater upwelling was reported along the south shore of the lake. Has there been any attempt to re-evaluate the significance of these events with respect to assumptions that net levee seepage and regional groundwater movement in the lake are small and therefore are not calculated in the model?" *CM/FJ.*

No.

"Is this assumption linked to the level pool assumption instead of one likely to be affected by wind set-up and other meteorological events as noted in literature effecting water surfaces profiles of large lakes and reservoirs?" CM/FJ.

No.

"Given the importance of operational plans for Lake Okeechobee in meeting CERP and C&SF multi-purpose objectives has any sensitivity analysis on the assumption of a flat pool elevation given the actual variability that exist?" CM/FJ.

No

How is SFWMM positional analysis used in making current operational decisions? Is the methodology included in the documentation for the SFWMM? CM/FJ.

Presented at operations meetings. Outside scope of Model review.

How can information learned through this process be implemented operationally and still be within the framework of NEPA coverage required as part of the operational planning process? CM/FJ

Outside scope of Model review.

Unanswered Questions

"How do biases in the model and low R-squared and efficiency values (e.g. L-31NC) at key monitoring points effect the interpretation of model results?" SMB

"If the coefficients that reduce maximum pumping need to be changed between the calibration and verification runs, will these coefficients be valid under different flow regimes?" SMB

"Because of the coarse spatial resolution of the SFWMM (2 miles by 2 miles), how will hydrologic information between finer resolution sub-regional and project scale models and the SFWMM be integrated in an iterative manner?" CM/FJ

"... it appears the variable [DETEN] is not necessary other than as a model parameter knob for refining calibration and verification. Would it not be better to just remove the variable thereby avoiding my confusion of its definition?" CM/FJ

"How is the assumption that overland flow does not occur in the Everglades Agricultural Area (EAA) justified given the fact that ponding exists? Because of order of magnitude differences between the flow rates, wouldn't this assumption affect the volume and timing of flows? Given the significance of flows to and from the EAA and their consequence to other constituents of the C&SF, has an attempt been made to establish a network of water level recorders or use agriculture's existing network in the calibration and verification of the EAA? Has similar information on flows from the extensive secondary drainage network been incorporated into the calibration and verification process? It seems that the hydrology of the EAA is equally as complex as the LEC canal network warranting the inclusion of secondary canals." CM/FJ

"Have the empirical formulas developed, for computing maximum allowable flows through the major EAA conveyance canals been verified with the most recent EAA flow data at major inlet and outlet structures?" CM/FJ

"Could using actual (non-repeating annually) tidal data for the coastal boundaries provide benefits without effecting impacting performance? Could this data be used during the calibration and verification process resulting in less uncertainty on simulated flows to tide?" CM/FJ

"Do the estimated values deviate from historical values in the context of the CERP implementation of reservoirs, aquifer storage and recovery technologies and the Kissimmee River Restoration Project? The SFWMM 1999 primer indicates that the modified-delta storage (MDS) term is composed of historical flows from S77, S308, L8, S352, S2, S351, S354, S3 and other lesser demands and runoff. It seems counterintuitive that some of these flows would be considered small enough that they would have a minimal effect on the overall Lake budget and thus could be assumed to not change during a simulation? This is particularly difficult to understand given that CERP may change the distribution of these flows. Granted the overall volume might not change but certainly the timing and distribution could which in turn would be expected to change ET and lake evaporation." CM/FJ

"What documentation is available in support of the assumption that evaporation from inefficient irrigation practices does not significantly alter the water budget of the saturated zone and can therefore be ignored in the SFWMM?" CM/FJ

"Is it reasonable to assume that, "due to the magnitude of a regulatory discharge through a single conveyance canal, the lake stage may drop to a level so as to significantly influence the amount of discharge through the next conveyance canal". Under what hydrologic conditions would the regulatory discharge of a single structure alter the storage of the lake when assuming a level pool?" CM/FJ

"How does the 5-acre parcel size ET-recharge data …… relate to the representative majority land use vegetation and crop coefficients at the coarser scale of the 2-by-2 mile grid cell resolution? Given a specific land use type how does a variation in mapping units vary as a function of different KVEG values?" CM/FJ

"What documentation is available that relates Lake Okeechobee historical flows and drainage on the north side of the lake with the data estimated using empirical methods?" CM/FJ

Appendix A: Reviewer Comments

Table 1. Contents of Review Comments

Name	**Alias**	**Agency**	**Date Received**	**Page**
Gwen Burzycki	GB	Miami-Dade DERM	7/29/02	A 2-3
Shawn Komlos	SK	US Environmental Protection Agency	8/13/02	A 4
Chandra Pathak	CP	South Florida Water Management District	8/16/02	A 5
Carl Woehlcke	CW	South Florida Water Management District	9/4/02	A 6
Michael Choate and Sam Lee	MC/SL	US Army Corps of Engineers	9/4/02	A 7
Mike Waldon	MW	US Fish and Wildlife Service	9/6/02	A 8-9
Gwen Burzycki	GB	Miami-Dade DERM	9/6/02	A 10-11
Callie McMunigal and Freddie James	CM/FJ	US Fish and Wildlife Service	9/12/02	A 12-20
Sherry Mitchell-Bruker	SMB	Everglades National Park	9/11/02	A 21-24

Note: Comments are presented in their entirety in the order received, except for comments by Sherry Mitchell-Bruker. Her comments are listed last because they included two appendices – which have been renamed appendix B and C to avoid confusion with this appendix.

Appendices B and C: Additional Information

Table 2. Contents of additional information.

Contents of Additional Information	**Page**
SFWMM subroutine small_res_gw_flow.F with example commenting by Sherry Mitchell-Bruker, ENP	B 1-4
Simulations from Stuart Stothoff's SEDFLOW model	C 1-7

Subject: RE: changes to 2000 land use map
Date: Mon, 29 Jul 2002 18:10:19 -0400
From: "Burzycki, Gwen (DERM)" <BurzyG@miamidade.gov>
To: Jenifer Barnes <jabarne@sfwmd.gov>
CC: 'Brenda Mills' <bmills@sfwmd.gov>, Ken Tarboton <ktarbot@sfwmd.gov>,
Tim Towles <tim.towles@fwc.state.fl.us>,
"Ferro, James (DERM)" <FerroJ@miamidade.gov>,
"Evoy, Jean (DERM)" <EvoyJ@miamidade.gov>,
"Markley, Susan M. (DERM)" <markls@miamidade.gov>,
"Blair, Steve (DERM)" <BlairS@miamidade.gov>

I looked over the SFWMM 2000 land use for natural areas in the Miami-Dade County area. This was a tremendous job and I extend my respect and appreciation to all of the staff who worked very hard to update the District-wide land use, given how fast it is changing and how hard it can be to find reliable information. I would like to point out the following issues/problems:

1) There are very few citrus groves in Miami-Dade County, but there are plenty of other tropical fruit groves. I recommend that this land use type be generalized to "Groves" or "Fruit Groves" to improve the accuracy of this label.
2) Cells labeled as "shrubland" in southeastern Miami-Dade County (there are three) are incorrect. All three of these are wetland areas and the various wetland regulatory programs all exert jurisdiction throughout those cells. The cell along the shoreline (R12 C31) should be either "Mangroves" or "Forested Wetlands" (it's a mix of mangroves, buttonwood, and Brazilian pepper dominated wetlands). The other two cells (R11 C29, R10 C28) should be "Forested Wetlands" - they are abandoned farmed wetlands vegetated with Dahoon holly, red bay, wax myrtle, and some Brazilian pepper.
3) Pennsuco wetlands should be coded as "Sawgrass plains" rather than "wet prairie". I checked the recent land use mapping under Miami-Dade County's Lake Belt Project and while the majority of the Pennsuco was mapped as "Prairie" or prairie infested with various levels of melaleuca, the definition of "prairie" includes both short and long hydroperiod wetlands, so is far too broad to be taken at face value. I consulted with older, more detailed maps of the area, along with wetland biologists who have spent a great deal of time in the Pennsuco, and all of these sources confirm that the Pennsuco consists of a mixture of dense and sparse sawgrass alternating with open areas containing some pickerelweed, duck potato, and/or bladderwort. This area was originally part of the Shark River Slough and clearly has a much longer hydroperiod than the Bird Drive, as evidenced by the heavy sawgrass cover. It should be mapped accordingly.
4) The cell that was previously tracked to represent the Bird Drive Recharge Area (R21 C28) is now mapped as "Medium Density Urban". We need some clarification on whether the cell to the west (R21 C27, which was

previously mapped as "Melaleuca" and is now mapped as "Wet Prairie") is now the cell that the model considers to be the BDRA. Modeling in this area has always proved problematic because the actual 4 square mile area comprising the bulk of the BDRA sits right under the intersection of 4 cells, thus none of them properly represents this crucial area.

Thank you for your attention.

Date: Tue, 13 Aug 2002 06:30:06 -0400
From: Komlos.Shawn@epamail.epa.gov
To: ktarbot@sfwmd.gov
CC: Hughes.Eric@epamail.epa.gov

Ken,
This e-mail is a follow up to conversations that occurred during the August 6, 2002 MRT meeting (WMM v5.0 presentation). I asked a few questions and made a few comments at the meeting that did not come across as clearly as I would have liked. I am hopeful that the following will provide any necessary clarification.

1) Is there a directional component (e.g., depth-dependent anisotropic factor) to the roughness coefficients for the various land use types (e.g., type I ridge and slough versus type V ridge and slough, predominantly north-south trending drainage canals versus predominantly east-west trending drainage canals, etc.)? Has this been considered before and/or is this being considered in the development of the RSM?

2) Given that the ET calculations have been converted to temperature-based formulae, to what extent will the influence of anticipated temperature differences be considered during the development of future-based alternatives/scenarios (e.g., according to the 2002 U.S. Climate Action Report, temperatures are projected to increase on the order of 0.6 ? 2.5 degrees centigrade by 2050)? Likewise, to what extent will the influence of those anticipated temperature differences be considered in the calculation of crop-irrigation demands? Given that the influence of sea-level rise (on surface water management) was simulated in scenarios of the 2050 baseline, and that sea-level rise is a response to temperature change, are ET sensitivity runs also anticipated?

As a "heads-up" I will likely be copying you on some ELM comments that I intend to send to Carl. I've got some questions about how flows and stages internal to the modeled ELM domain might be "forced" by adopting flows from the 2x2 (and potential issues related to operating ELM with dynamic vegetation). I don't know enough about which structure flows are imported versus simulated in the ELM and am trying to get a bit more up to speed before I submit those comments. The above-referenced comments will likely be included in the e-mail to Carl as well.

Sincerely,
Shawn Komlos
Environmental Scientist/Fish and Wildlife Liaison
United States Environmental Protection Agency, Region 4
South Florida Office, 400 North Congress Avenue, Suite 120
West Palm Beach, Florida 33401

COMMENTS FOR RECOVER-MRT MEETING DATED 8-06-02 ON

SFWMM MODEL V 5.0 CALIBRATION AND VERIFICATION

1. Several CERP projects have recently completed development of their respective performance measures. This team needs to consult CERP project managers and obtain the performance measures and identify performance measures that are applicable and directly tie into the SFWMM model results. For these projects, all the common and un-common applicable performance measures should be developed and analyzed. For these two groups of performance measures, a post-processor template which interfaces with SFWMM model results should be developed. This template should be reviewed by CERP project managers and provide their feedback such that template meet or exceed the expectations from the identified and applicable performance measures for their evaluations.

2. Several stations are used in the model calibration in each basin. The modelers need to identify the stations (used in the model) where stream gauging data are available from the District and/or from USGS. At these identified stations, the performance of the model need to evaluated and improved, if necessary, during the calibration phase. Furthermore, the modelers should identify and rank limited number (say 10 to 15) of additional stations where stream gauging data would be useful in improving the performance of the calibrated model based on modeler's experience. Then, the team should forward these identified stations (for stream gauging) to the appropriate agency (District or USGS).

3. The SFWMM model results are sensitive to the rainfall data. Specifically, spatial variations in the rainfall data are very important for modeling purpose. We have NEXRAD data available to us from 1996 to 2000. For further analysis, the calibrated model should replace the point-rainfall data with NEXRAD dataset. Then, the revised model should be fine-tuned (from 1996 to 2000) and compared with the results of the previous model (which used the point-rainfall data) for the same period-of-record. This process is expected to improve the performance of the calibrated model furthermore.

Subject: Suggestions for Water Management Model Improvement
Date: Wed, 04 Sep 2002 10:20:07 -0400
From: Carl Woehlcke <lwoehlck@sfwmd.gov>
Organization: South Florida Water Management District
To: Ken Tarboton <ktarbot@sfwmd.gov>
CC: Stanford Ford <sford@sfwmd.gov>

Ken,

I think you have already heard all of the following suggestions for SFWMM improvements.

1. Incorporate appropriate accounting for seepage water from reservoirs located north of Lake Okeechobee and for return flows due to irrigation withdrawals from Lake Okeechobee into the Lake Okeechobee Watershed. (Modeling of these basins as part of the LOW PIR may allow you to incorporate model results instead of having to make assumptions.)
2. Incorporate appropriate accounting for irrigation water delivered to the big Cypress Seminole Reservation or adjust deliveries to meet supplemental ET needs rather than gross irrigation withdrawals.
3. Consider adjusting the effect of utility pumpage on water budgets in the coastal basins. Utility withdrawals are not all lost to the system. Investigate the average and marginal ratios of wastewater disposal (deepwell and ocean outfalls) to utility pumpage. Be sure to explicitly include the effect of all expected wastewater reuse on the surface water/surficial aquifer water budgets.
4. Be sure to incorporate the latest and best information regarding the effects of BMPs in the EAA on ET.

Would this input be useful to the Model Refinement Team? Can you convey it or should I go the formal comment route?

Carl

Carl Woehlcke <lwoehlck@sfwmd.gov>
Lead Economist
South Florida Water Management District
Program Management Department, Restoration Program Division

CESAJ-DR-R 4 Sept. 2002

To: MRT Model Review Group: Ken Tarboton and Sherry Mitchell-Bruker

SUBJECT: Review Comments SFWMM v.5.0

Questions:

1) How does the model period-of-record (POR) of 1965 to 2000 compare with the available longer POR (ie. NCDC 1895-2000)? An exhaustive statistical analysis is not requested. Instead, long term averages or running means would give general information about model period used to design system wide project features.
2) Calibration to gages in the urban LEC areas generally under predict the higher peak stages. Note calibration plots of gages PB732, PB831, F291 and S-196A. Since this appears to be systematic in the urban areas what do you perceive to be the problem and is it fixable?

Concerns:

1) Lack of saltwater density head impacts at the coastal boundaries.
2) Lack of ability to calibrate groundwater and surface water flow rates.

Appropriate Use of the Model and Model Limitations:

Spatial scale of cells and structured rectangular grid limit the model to a planning and water supply function, which it does very well. The model is appropriate to provide head boundaries to other models, but has limited ability to provide flow boundaries.

Critical Recommendations:

None

Non-Critical Recommendations:

A density correction could easily be applied to tidal boundaries.

Reviewers: Michael Choate 904-899-5031; Samuel Lee, Ph.D. 904-232-1381

SFWMM Review Comment and Questions
Mike Waldon, USFWS/DOI EPT
September 6, 2002

Questions

Model Quality Assurance

Does the SFWMD have a model quality assurance plan?

Do you follow procedures for model self-documentation (commenting)? Is there a prescribed style for commenting programs and procedures?

Is model input self-documented?

How was the model tested to locate programming or model structural errors in the code? For example, has the model been run for special cases such as constant parameters to determine if steady-state levels agree with analytical calculations? Is this testing documented? When new procedures are added to the program, what testing procedure is followed?

Does the model include tests (either internal or in a pre- or post-processor) that flag errors or provide warnings? For example, is it possible to cause the model to fail to conserve mass through errors in the input datasets, and would this failure be flagged? Are unusually high velocities or discharges flagged?

Are there conditions under which the WMM model is unstable?

Do you maintain a list of known bugs?

Concerns

Model calibration of the WMM (and ELM) involves imposing historic flows at all interior structures. This substantially limits the propagation of errors from one impounded area to downstream areas. Although seepage transfers between impounded areas provides some connection, simulation errors that occur in CA-1, for example, do not result in erroneous S-10 structure flows into CA-2. Model projections of future conditions must simulate structure flows using management rules. This calibration approach works to minimize calibration errors and may inappropriately influence our estimate of model accuracy. How could this problem be quantified? Could structure flows be adjusted using structure rating curves and model stage

error(s) such that when headwater stage is underestimated by the model the resulting structure flows would be reduced? How can this calibration error question be otherwise addressed? How can it be quantified?

Model Limitations

Appropriate Use of the Model

Critical Recommendations

Many of our performance measures may be most sensitive to extreme events that last for relatively short periods. From just a visual scan of plots, it appears to me that the model may be least well calibrated during extremes, and fits best during more typical conditions. Calibration metrics should therefore be reported for both modeled versus observed performance measures. For example, if a PM is number of days below 12 feet elevation each year, the annual errors should be evaluated to estimate performance of the model. As a second example, a PM of total annual volume of STA bypass flow could be estimated using the historic flow record and assumptions on STA capacity and availability, and compared to WMM predictions. In this second example, the ability of the WMM to simulate peak flows is crucial to gain an accurate estimate of bypass.

Non-Critical Recommendations

Miami-Dade DERM Comments
RECOVER - MRT Review of SFWMM
August 2002

Questions

Land Use.

Given the scale of the model and the rapidly changing urban landscape, there are likely to be disputes and/or errors in the land use classification. Correction information is likely to come in a little at a time, as people work with the model and become familiar with land use classification in specific cells. How will the updating be handled, and will it affect the scheduling for calibration runs, etc? Are periodic minor changes such as this clearly documented and at what point would it constitute an updated model version?

Specific example questions: What magnitude of error or uncertainty would be introduced if an area that should be actually classified as sawgrass plains is classified as wet prairie (e.g. Pennsuco)? What magnitude of error or uncertainty is introduced if an area classified as an upland land use is really wetland (e.g shrubland in Model Lands area of Miami-Dade County is actually forested wetlands; several agricultural regions in Miami-Dade are located in jurisdictional wetlands, with wetland regulatory permits on file for these businesses)?

We are concerned about the use of the Welch et al. information for land use within ENP because we have repeatedly heard that there are errors in the mapping, although we do not have good information about either the extent or magnitude of the errors. Was the use of this source of information supported by ENP staff?

Which cell is being modeled as the Bird Drive Recharge Area?

Rainfall. What rainfall value is considered threshold for extreme? (Extreme rain values are checked against nearest neighbors before accepting.) Given the patchy nature of wet season rainfall combined with the possibility for substantial rainfall from a single thunderhead, this threshold is very important in setting a filter for high rainfall events.

Pre-storm drawdown function. If the LEC region is experiencing strong southeasterly winds, the ability of operations managers to actually reduce water levels in advance of a storm is limited (e.g. Hurricane Irene). Does this feature include consideration of wind direction?

Calibration vs. predictive runs. There was discussion at the presentation indicating that predictive runs may change a parameter sufficiently that it now falls outside the range for which the model was calibrated. Has this ever been a problem, if so to what degree has it been a problem, and if this has the potential to be a significant problem, is there any way to compensate for it?

Concerns

Output in Coastal Areas. Recent information from SICS model development indicates that density transport functions are very important to critical for calibration in salt intruded areas. The SFWMM does not have this function, yet its output is being used to judge performance in coastal areas because there is no other system-wide tool available.

Rainfall. Rainfall is extremely patchy in some of the wet season systems and the rain stations do not seem close enough to provide adequate nearest-neighbor validation for extreme rain events.
Scaling Issues. We are concerned about the continuing trend for requesting that the SFWMM be able to model features that are really too small for the model to "see".
Uncertainty in coastal structure flows. Surface flow data for the coastal water control structures is notoriously uncertain. This is resulting in problems with calibrating the model for discharges to tide. Since there is no link to a downstream estuary model that could provide a check on the flows by reading back the resulting estuarine salinity, there is no way to verify whether the model is providing realistic canal flows.

Model Limitations

No comments at this time.

Appropriate Use of the Model

No comments at this time.

Critical Recommendations

Output in Coastal Areas. A suitable tool is needed to support RET evaluations in the coastal areas. Either some means should be found for expanding the SFWMM model out into open water, or a companion tool (to be used in conjunction with the SFWMM) should be developed that provides reliable information on the model boundary. Hydrodynamic models, such as the Biscayne Bay hydrodynamic model, that simulate coastal physical scenarios could be used as companion tools to evaluate flows to the coastal regions.
Scaling Issues. Given the confusion that can result if the SFWMM output for small features is substantially different from output provided by smaller scale models (e.g. Bird Drive, Pennsuco results for WPA), perhaps there should be a "line in the sand" where HSM is authorized to refuse to incorporate a feature because it is just too small. Alternatively, since the effort to create a new generation model with finer resolution is underway but will take time, it might make sense to somehow nest a finer scale model into these areas that would appropriately model such features and then feed output back to the larger scale model.
Uncertainty in coastal structure flows. Data on flows to the coast from project canals must be improved. This is a data collection issue that is critical to improving confidence in model output.
Data Collection to Support Model Improvements. The RECOVER MAP did not consider model improvements as a goal in the monitoring plan, so a separate data collection effort is needed that will support appropriate improvements to this and other models used for CERP.

Non-Critical Recommendations

Rainfall. There is always a need for better rainfall data in areas with highly patchy weather systems. Continuing support for improving methods to evaluate rainfall in this region.is recommended. The use of NEXRAD data should be explored as a possible solution.

The assigned task by the Model Refinement Team (MRT) is to review the South Florida Water Management Model (SFWMM) documentation including calibration and verification data in the context of regional hydrologic evaluations of the structural, feature and operational criteria modifications proposed in the Comprehensive Everglades Restoration Project (CERP). To be successful in this endeavor would require an enormous effort beyond the current resources of the U.S. Fish and Wildlife Service. Therefore, the Service has attempted to provide a balanced review with the resources available with the caveat that it reserves the right at some future time to raise objection if it is determined that application of the SFWMM is inappropriate and potentially inconsistent with achieving CERP ecological objectives.

At the onset it is important to note that the SFWMM is the only existing hydrologic model at the spatial extent of CERP, capable of simulating both the natural and managed hydrology of south Florida. This capability and the models ability to simulate the complex water management operational criteria associated with Central and South Florida Flood Control Project (C&SF) for flood control, water supply and environmental objectives has resulted in its previous and proposed application in a number state and federal water resource projects noted by Santee (SFWMD, 2002);

- Development of the Draft Lower East Coast Regional Water Supply Plan (SFWMD, 1993) (V2.10)
- Central and Southern Florida Flood Control Project Comprehensive Review Study Final Integrated
- Feasibility Report and Programmatic Environmental Impact Statement (Restudy) (USACE and SFWMD, 1999) (V3.5)
- Lower East Coast Regional Water Supply Plan (SFWMD, 2000) (V3.7)
- Water Preserve Area (WPA) Feasibility Study (V3.5)
- Interim Structural and Operational Plan (ISOP) (V3.8)
- Modified Water Deliveries (New Combined Structural and Operational Plan – CSOP) (V3.7, V4.4)Operational Planning (V3.8-V4.4)

What is the purpose of this first level of MRT technical review of the SFWMM ?

1) To provide a first level review of the SFWMM through the development questions similar to those posed in the 1998 peer review of the DRAFT SFWMM documentation, January 2002 MRT uncertainty workshop and along the lines of the May 5, 2002 MRT questionnaire to model developers.
2) Review the existing information available on the SFWMM and determine whether it will meet CERP regional modeling current and future needs.
3) Identify areas potentially requiring more rigorous and thorough technical review only achieved through a formal peer review process.
4) Provide positive feedback to the MRT through critical and non-critical recommendations on areas of outstanding concern on model limitations and appropriate use of the model.

What is not the purpose of this review is to provide a higher level of review typically associated with a technical peer review similar to that undertaken in 1998. Specifically, that review of the 1997 Draft Documentation for the South Florida Water Management Model (SFWMM) consisted primarily of the following;

- Develop a series of questions, issues and areas for discussion during a site visit,
- Visit the District for a model familiarization session, and
- Prepare and submit a written evaluation of the model, with emphasis on the documentation that will include criticisms, specific recommendations for improvement, and responses to questions posed.

Their findings were reported in four general sections; clarity and appropriateness of model documentation, hydrological processes, model calibration and validation or verification processes, and overall appropriateness of model. This earlier review however, may provide an initial framework from which to build upon during the current review. Likewise, the current review does not attempt to address technical issues surrounding uncertainty in application of the SFWMM and sensitivity of the model to input parameters and assumptions. However, information reported in the "Quantifying and Communicating Model Uncertainty for Decision Making in the Everglades, Report of the Comprehensive Everglades Restoration Plan's Model Uncertainty Workshop January 15 – 17, 2002" conducted by the MRT may provide important direction in the current review.

For the Service perhaps the most important task is integrating the recommendations from these two sources into our review from the perspective of fish and wildlife considerations for each of the MRT solicited categories; questions, concerns, appropriate use of the model, model limitations, non-critical and critical recommendations. Each of these in turn could fall under SFWMM documentation, input data, calibration and verification, and utilizing output as hydrologic attributes for ecosystem evaluations i.e. performance measures, structural and feature modification, or operational planning purposes. Additionally, the MRT shares responsibility in defining the linkages between application of the SFWMM and sub-regional or project scale models. The key for the Service is to narrow our efforts in the review of the SFWMM to specific examples of its application most likely to affect the Service's decision making process at some future date. Unfortunately, Service evaluation is required on almost every CERP component, which in some form or other may ultimately be input into the SFWMM for regional assessment of impacts or benefits.

We concur with earlier reviewers in acknowledging "the difficulties in committing adequate time and resources to keeping current the documentation of any model that is periodically being changed and updated". Given the frequency of change and revisions to code and input that the SFWMM has undergone during the last few years, one assumes that there may have been significant changes made to the model. Even though the purpose and intended application of the model has undergone little change, documentation should be updated to include recent revisions associated with each new version. We recommend a more complete technical review of the SFWMM be initiated.

Comments

A reference map with canal locations and gauges used in calibration and verification gauges would be extremely helpful.

A reference map of rainfall gauges used for generating the daily rainfall binary files with reference table of period of records would be extremely helpful.

The ability to review the effects of changes of topography in the EAA and the central and Everglades on hydrology would be greatly enhanced by the inclusion flow calibration and verification graphics similar to those provided in the SFWMM V3.5 primer (SFWMM, 1999).

It would be helpful if a table of input parameter values was available that compared the degree of change between v3.5 and v5.0. This information could than be used to determine the degree of change for the new land use classifications from the initial values suggested in Table 2, page 19 of the June 5, 2002 memo "Final Land Use Coverage for SFWMM 2000 Update."

The Santee May 19, 1999 memo states, "**2050 BASE"**. Tailwater constraints due to stages at G3273 location for S-333 flows to NESRS have been refined as in the 95BASE. S-355 discharges are subject to stage constraints at G3273 gage location, as well as in L-29 borrow canal." For the 2050 Base one would assume that S-333 flows should not include the G-3273 constraints of 95Base, nor should the S-355. Completion of the Modified Water Deliveries Project is assumed in the 2050. It is possible that an L-29 constraint may exist in 2050 because of flooding concerns associated with Tamiami Trail road bed. However, it is believed that it is 9.0 ft rather than 7.5ft. The change in these criteria would be expected result in increased flows to Northeast Shark Slough via either S-333 or S-355, possibly warranting re-evaluation.

Questions

Where is G-56HW and why does its calibration and verification look like it does?

Why does PB831 calibrate reasonably well yet the verification looks like it does?

Why in some canal calibrations are HW for the structure referenced and than in verification WS for the structures are referenced? Such notation lends to one presuming that there are two different canal stage stations between the calibration and the verification runs, no?

Why does the calibration and verification for the Lower East Coast (LEC) generally miss the extremes, both high and low? How confidently can we evaluate conditions associated with extreme events as they relate to flood control and water supply? Particularly with respect to water supply, wouldn't the SFWMM's failure to simulate the frequency of low canal stage events and their duration have implications in the design of water storage facilities perhaps leading to under-estimates of needed storage? Given the appearance of maintaining a minimum canal elevation that is not evident in the historical data, wouldn't it be reasonable to assume simulations result in more water coming from the regional system than in actuality? How are these factors integrated into the performance measures used in assessments? Or do we even need to since the assumption is alternative assessments are relative comparisons to each other? Even still the larger question is what level of confidence do we have in the operational criteria that result in the apparent under-estimation of these extreme events?

How are triggers for declaring water use restrictions and LEC phased cutbacks calibrated and verified? If the goal of "the calibration process is to mimic the duration and intensity of historical water restrictions" why isn't a discussion of the methodology with corresponding metric available in the ***calib_verif_plots_v50.pdf*** or included in the 1999 SFWMM primer (SFWMM, 1999)? What documentation is available that shows the correlation between canal and SFWMM trigger well stages and the inland migration of the higher salinity levels that are presumably the basis for triggering water use restrictions?

What steps are taken in the calibration and verification to ensure that "history matching" occurs spatially and temporally between the occurrence of rainfall, stage and flows? It seems an important point to check that rainfall events occurring within a basin produce temporally correct levee seepage and canals flows with respect to magnitude and sequencing of stages? This is especially important on the boundaries between the WCA's/ENP and LEC.

Calibration and verification of 3B-SE hints that there is reason for concern particularly in light of the observed versus simulated S-335 HW stages. One might also expect concern with the flows as well.

Calibration and verification of gauges in the Water Conservation Areas (WCA) removed from the direct influences of water management structures appear to indicate that simulated water levels have better temporal correlation with observed data. Is it possible that the assumptions of EAA do have undesirable consequences with respect to the timing and volume of flows. How is this potentially compounded by the lack of calibration and verification data for the STA by-pass simulated flows? Could this data be passed to other regional or sub-regional models?

Obviously, best professional judgment is always going to be present during the determination of representative majority land use for scaling up to the 2-by-2 mile grid cells from satellite and finer resolution land use maps. Are there plans to automate the classification of satellite imagery and detailed land use maps in the future for more quantitative assessment of errors or uncertainty introduced during this process? How does the 5-acre parcel size ET-recharge data and the sensitivity analysis performed by M. Irizarry relate to the representative majority land use vegetation and crop coefficients at the coarser scale of the 2-by-2 mile grid cell resolution? Given a specific land use type how does a variation in mapping units vary as a function of different KVEG values? It would be useful to express the analysis in graphical form, rather than in tabular form.

How has the information generated from the uncertainty workshop been integrated into an uncertainty and sensitivity analysis of the SFWMM inputs and performance measures developed to date for regional evaluations?

Because of the coarse spatial resolution of the SFWMM (2 miles by 2 miles), how will hydrologic information between finer resolution sub-regional and project scale models and the SFWMM be integrated in an iterative manner?

A potentially critical factor affecting ponding in wetland areas and overland flow within the central and southern Everglades is the model parameter Detention depth (DETEN). From an

ecological perspective one might expect this parameter to be strongly correlated with aquatic refugia, associated with for example the karst topography of the Rocky Glades. Another way that DETEN might be viewed is the micro-topography embedded with the 2X2 mile grid. From the June 5, 2002 memo "Final Land Use Coverage for SFWMM 2000 Update" it appears the variable is not necessary other than as a model parameter knob for refining calibration and verification. Would it not be better to just remove the variable thereby avoiding my confusion of its definition?

How is the assumption that overland flow does not occur in the Everglades Agricultural Area (EAA) justified given the fact that ponding exists? Because of order of magnitude differences between the flow rates, wouldn't this assumption affect the volume and timing of flows? Given the significance of flows to and from the EAA and their consequence to other constituents of the C&SF, has an attempt been made to establish a network of water level recorders or use agriculture's existing network in the calibration and verification of the EAA? Has similar information on flows from the extensive secondary drainage network been incorporated into the calibration and verification process? It seems that the hydrology of the EAA is equally as complex as the LEC canal network warranting the inclusion of secondary canals.

Have the empirical formulas developed, for computing maximum allowable flows through the major EAA conveyance canals been verified with the most recent EAA flow data at major inlet and outlet structures?

Could using actual (non-repeating annually) tidal data for the coastal boundaries provide benefits without effecting impacting performance? Could this data be used during the calibration and verification process resulting in less uncertainty on simulated flows to tide?

During extreme high water events in Lake Okeechobee in the late 1990's, significant levee seepage and groundwater upwelling was reported along the south shore of the lake. Has there been any attempt to re-evaluate the significance of these events with respect to assumptions that net levee seepage and regional groundwater movement in the lake are small and therefore are not calculated in the model?

Is this assumption linked to the level pool assumption instead of one likely to be affected by wind set-up and other meteorological events as noted in literature effecting water surfaces profiles of large lakes and reservoirs?

Given the importance of operational plans for Lake Okeechobee in meeting CERP and C&SF multi-purpose objectives has any sensitivity analysis on the assumption of a flat pool elevation given the actual variability that exist?

Assumptions about Lake Okeechobee's water surface and historical flows prohibits integration of calibration and verification of lake stages which seems counter-intuitive given that some quality control and assurance of the validity of the assumptions are necessary.

What documentation is available that relates Lake Okeechobee historical flows and drainage on the north side of the lake with the data estimated using empirical methods?

Do the estimated values deviate from historical values in the context of the CERP implementation of reservoirs, aquifer storage and recovery technologies and the Kissimmee River Restoration Project? The SFWMM 1999 primer indicates that the modified-delta storage (MDS) term is composed of historical flows from S77, S308, L8, S352, S2, S351, S354, S3 and other lesser demands and runoff. It seems counterintuitive that some of these flows would be considered small enough that they would have a minimal effect on the overall Lake budget and thus could be assumed to not change during a simulation? This is particularly difficult to understand given that CERP may change the distribution of these flows. Granted the overall volume might not change but certainly the timing and distribution could which in turn would be expected to change ET and lake evaporation.

How is SFWMM positional analysis used in making current operational decisions? Is the methodology included in the documentation for the SFWMM? How can information learned through this process be implemented operationally and still be within the framework of NEPA coverage required as part of the operational planning process?

Pre-processing irrigation and run-off demands seems counter intuitive with alternative testing of operational, structural, and feature modifications where depth of the water table is unknown previous to simulation runs. It is difficult to communicate why, but it seems that it predefines a level of service, which in turn results in a volume either retained or removed from storage, which may or may not be what actually occurs. It is easy to visualize pre-processing the total net irrigation application depth, which is independent of the position of the water table but not ETU, evapotranspiration from the unsaturated zone. Isn't the depth to the water table a variable which is not known prior to simulation of an alternative? If it is, what simplifying assumptions are made to generate the spatial temporally variable water depth information used for ETU pre-processing at daily time step and land use mapping scale of 5, 20 and 50 acres?

What documentation is available in support of the assumption that evaporation from inefficient irrigation practices does not significantly alter the water budget of the saturated zone and can therefore be ignored in the SFWMM?

When was the last effort to recalculate levee seepage coefficients determined through regression analysis? Since levee seepage represents a significant contribution to the overall water budget, wouldn't adjustment through calibration with verification of these coefficients on a continuing basis be desirable?

How is the concept of "borrowing" in supply-side management applied to other consumptive water users? It seems difficult to reconcile the appropriateness of "borrowing" because of the appearance that the practice may create larger deficits later in the dry season. Such deficits would seem to be of concern as potentially they could be amplified with increasing severity of the drought, unknown at the time of the "borrowing". Since "borrowing" is used early in the dry season during periods of deficit rainfall what might the implications to other users be if the payback, due later in the dry season is not available? Is there a mechanism in the SFWMM to ensure that source water is not available to those no longer entitled while still delivering water to those who it is due? Are there any mechanisms in the model to assess the significance of "borrowing" with respect to inherent policy changes characteristic of drought events? How is

"borrowing" calibrated and verified? Does borrowing have the potential to impact the quantification of water rights in CERP?

Is it reasonable to assume that, "due to the magnitude of a regulatory discharge through a single conveyance canal, the lake stage may drop to a level so as to significantly influence the amount of discharge through the next conveyance canal". Under what hydrologic conditions would the regulatory discharge of a single structure alter the storage of the lake when assuming a level pool?

Model Limitations and Appropriate Use of the Model

The following statements found in uncertainty workshop document (Uncertainty Workshop, 2001) are relevant in the context of the calibration and verification data but may be more important with respect to limitations and application of the model.

"As a consequence, the parameters are judgmentally chosen and model fitting becomes an art; more experienced modelers/artists will produce better fitting models. These models are designed to describe typical or average behavior; thus it is reasonable to expect that a good process model will yield a prediction trajectory that goes through the middle of the time series of observations, once the model is fully parameterized. Presumably, as more processes are adequately represented in the model, the model time trajectory will begin to capture the short-term fluctuations in the observations more accurately. However the model might be expected to underestimate the extremes, since its structure is more compatible with the central tendency. This point is important because it implies that parameter selection aimed at fitting the extremes (e.g., effects of high water levels on tree islands) is incompatible with the model structure that is designed to describe average system behavior."

The model's intended use is as a long-term planning tool for guidance in water policy decisions by water managers. It has been often inferred that the model is not intended to estimate system response to extreme conditions seems contradictory. The reality is these events are what water managers manage for and in almost every one of the resource projects noted day-to-day operational criteria have been shaped based on output from the model. Likewise these hydrologic conditions are what often fuels the hydrology that drives ecological and biological processes. Therefore, implementing calibration and verification of metrics, for ecological, flood control and water supply purposes specific to such events are essential, if confidence in simulated operational criteria are to be achieved with their implementation.

Non-critical Recommendations

In the SFWMM primer (SFWMM, 1999) the introduction section of the general description chapter indicates that "strengths and weaknesses" will be included with complete description of the model characteristics and hydrologic processes and simulation methods. A scan through of

the document leaves many instances where the user of the model could come away without a clear indication its "strengths and weaknesses." Because of its wide use and application for many water resource projects, it might be helpful to codify the uses or applications in the form of performance metrics in an appendix as illustrative examples for reference. The main purpose of this addition would be to indicate areas of reasonable accuracy and of less than desired accuracy. This may reduce the likelihood of the model being used to evaluate performance measures for which it is unsuited. The electronic age provides unique opportunities as well. A large part of this review was only possible through the digital information made available by the SFWMD as part of the MRT review process. It would have been extremely helpful, albeit time consuming to have more of the literature cited, including the internal memorandums available. If a balance can be struck between the resources necessary in acquiring and collating the wealth of information available versus the cost in time and lost productivity over the long run it would an enhance the product.

The section on Stormwater Treatment Areas including Best Management Practices needs to be described in more detail particularly with respect to the source, destination and calculation for by-pass flows.

As a model user, the updated documentation of input files has been extremely helpful. It would be also useful to know how canals, structures, wells, and other structural feature including operational criteria data within the individual input files are linked to each other in terms of dependencies.

Critical Recommendations

The documentation should be updated to include the new WSE schedule for Lake Okeechobee including adequate description of the algorithms used to simulate the decision tree.

Since the inception of the SFWMM in the 1970's the SFWMD has gone to great lengths in providing information about the model including source code, input and output, documentation, and calibration and verification data. In addition, they have initiated a series of training workshops to provide more in-depth and thorough explanations.

Since the SFWMM is used to address both design and policy issues for the complex hydrology of south Florida, calibration and verification for the major components should include both flows and stages. The calibration and verification should attempt to capture the "central tendency" as well as the 'extremes" of the important hydrologic characteristics at a landscape scale for Lake Okeechobee, the EAA, WCAs, ENP and LEC resulting from modification of the operational and structural features.

Along the lines of the information presented in the uncertainty workshop and documentation, more emphasis should be placed on spatial and temporal variations of climatic events and the range of operational strategies the model is capable of simulating and evaluating. (For example questions such as "how 'big' does a structure have to be before the SFWMM can model its impacts", and "how 'major' does a change in operational strategy have to be before the model can distinguish its effects?" need to be addressed in this section.) In the past the model has been

used to predict changes in regional hydrology associated with changing the canal operational levels by tenths of a foot. Is the model capable of accurately distinguishing between these types of subtle operational changes?

More rigorous defense of the level of sophistication chosen to model each process (and for choosing different levels of sophistication to model the same process in different regions) would strengthen the documentation. Decisions regarding the level of sophistication required for modeling different hydrologic processes seem to have been made for practical (i.e. computational efficiency) reasons based on the modelers' collective intuition and hydrologic experience in the region.

Some appropriate figures and tables could highlight where the model performs well, and where it does not perform so well. These figures should show which performance measures the model can reasonably simulate and which it cannot address at this time.

Review of South Florida Water Mangement Model 2000

Sherry Mitchell-Bruker
Everglades National Park
09-11-02

Everglades National Park is providing comments for the Recover Model Refinement Team (MRT) agency review of the South Florida Water Management Model (SFWMM). These comments are directed towards a few very specific items and a some more general comments on the model changes and calibration in general. These comments do not substitute for a more thorough peer review, but is intended as a first step in a more rigorous review process. The SFWMM represents the best (and only) available tool for modeling the regional distribution of groundwater and surface water in South Florida. It is a planning model that can be used to provide an approximate estimate of the distribution of flow volumes and stages over a 7600 square mile area and a 35 year simulation. The 6.8 billion dollar CERP plan development relied heavily on the SFWMM as do the ongoing restoration efforts under CERP and Modified Water Deliveries. Because of the important role that the SFWMM has played and will continue to play in Everglades restoration efforts, it is essential that the model be thoroughly documented and reviewed. The model limitations must be identified and accepted and the uncertainty in the model output must be quantified. The MRT review should be just the beginning of the model review process.

This review will be focused on updates to the model but will also include aspects of the model that have not changed. Previously, the model documentation has been reviewed but there has not been a rigorous review of the model code, the model assumptions and the model results. Given the size and complexity of code, the many undocumented and undefined parameters and coefficients, and the heavy reliance on the model for Everglades restoration; Everglades National Park recommends an external detailed review of the SFWMM2000 application. The comments and concerns provided in this review represent only a subset of the areas of concern that might arise under a more extensive review.

Limitations and Appropriate Use

The model is primarily a planning model, which can be used to compare alternatives and predict trends in water distributions. The model incorporates the complexities of the water management schemes but does not rigorously calculate the water balance. Because the model has been calibrated to match heads, it is most reliable in simulating heads under flow regimes that are not drastically different from the calibration flow regime. The calibration often requires adding adjustment factors that have no physical basis, but compensate for processes that are not explicitly represented in the model (for example, operator judgement). Therefore the model is most useful as a planning tool to compare scenarios that do not vary drastically from the calibration operations.

The 2x2 mile cell size of the model is also a severe limitation. Subtle gradients in topography that have significant ecological implications cannot be represented in the model. In addition, reservoirs and impoundments that are narrower than the grid cell are modeled in a approximate manner, calculating the reservoir capacity and spreading the volume of water added across the cell. This small reservoir code requires further review and documentation. A finer scale model is required to adequately simulate small reservoir impacts and benefits. The scale limitations of the SFWMM also limit its use in flood impact assessments and structure design.

Critical Recommendations

1. Apparently there is no run-time global mass balance check on the model. This is of great concern, given the highly non-linear feedbacks that are known to occur between the groundwater, surface water and canal systems. The non-iterative approach taken in this model is not likely to provide for a solution that achieves mass balance throughout the domain and could lead to highly unreliable predictions regarding the volumes of water that are provided for the estuaries and water supply. The errors associated with this approach must be quantified. One way to determine this error is to add a global mass balance check as a convergence criteria. The model should be iterated until mass balance is achieved or a maximum number of iterations has been reached. If the maximum number of iterations is reached and the model has not converged, the convergence criteria is increased and the model continues to iterate. Eventually the model should converge and the final convergence criteria is a measure of the global mass balance error. If the model never converges, this is an indication of a severe problem with the model.

2. The model does not simulate density-dependent effects at coastal boundaries, which are known to be significant. By calculating an equivalent fresh-water head at the coastal boundary, the density-dependent effects can be approximated. This is a relatively simple modification and should be implemented in the near future.

3. Ridge and Slough land use changes are based on an assumption that there is less resistance to flow in landscapes that have less directionality. This assumption is untested and is particularly unrealistic in northeast Shark River Slough (NESRS).
   The effect of the linear surface features is that of an anisotropy in the flow resistance term. If the flow is in the direction of the anisotropy, the linear features may cause some decrease in the resistance to flow, but as the flow direction departs from the direction of anisotropy, the effect of the linear features is to change the direction of flow. A change in the mannings coefficient does not emulate this effect. Appendix C contains model simulations from Stuart Stothoff's SEDFLOW model that confirm this hypothesis.

   The land use coverage document posted at the SFWMM website indicates that in Northeast Shark River Slough, the land use is specified as Ridge and Slough II, which is assumed to have less resistance to flow than other areas with less directionality. However, in NESRS, there is a strong gradient from west to east, moving flow perpendicular to the southwest linearity of the ridge and slough and tree island features. It is inappropriate in this area to assume that resistance to flow is less than in other areas.

In fact, in the water conservation areas, where water tends to be deep, resistance to flow is most likely to be less than in the sawgrass-dominated sloughs where linear ridge and slough features are more evident. In general, the assumptions that are made regarding the various ridge and slough landscapes are not supported by data and should not be used in the calibration.

The calibration could be improved by including an anisotropy term in the overland flow equations, which could have an important effect on flow directions in the SFWMM and the NSM model. However, before such a term is introduced, further analysis should be undertaken to provide a quantitative assessment of the ridge and slough effects. We would be pleased to work with the SFWMD to improve the SFWMM in this regard.

Concerns

1. The material posted on the model website is not sufficient for a thorough model review.
    - The map of the calibration targets shows many water level calibration points, however the plots and the statistics for each of these points were not provided. The entire set of calibration plots and statistics should be posted with the review materials.
    - The calibration input and output files should be posted with the review materials.
2. The source code documentation is incomplete. There are hundreds of variables that are undefined. Many variables have non-descriptive names. For example, the variable sfactor is found 304 times in the code, however it is not defined in the code and it is not clear without spending hours delving into the code what this variable is used for. Before further review efforts, all of the variables and parameters in the code should be defined. Equations and formulations that are used should be provided in the source code. Appendix B is a copy of the file small_res_gw_flow.F with comments (labeled smb) indicating locations where more comment is needed. Many of the files need similar improvements in the source code documentation.
3. Documentation of input data. The documentation of the input data is generally good, although there are a few files with gaps in the documentation.

Questions

Why is the model insensitive to the coefficients that increase the amount of direct seepage from small reservoirs to the canal?

How do biases in the model and low R-squared and efficiency values (e.g. L-31NC) at key monitoring points effect the interpretation of model results?

If the coefficients that reduce maximum pumping need to be changed between the calibration and verification runs, will these coefficients be valid under different flow regimes?

Calibration Verification Report

A calibration-verification report should accompany each major model release. This report should include a description of source code changes, input data set changes and a description of how coefficients and parameters were adjusted during calibration and verification. Plots of relevant calibration targets should be provided before and after parameter adjustment. In the event that changes in parameters and coefficients are made for the verification run, the departure of operations from the model operations should be demonstrated with data or written explanations.

Since the calibration uses measured flows at the structures, there is no calibration process to assure that the equations used to simulate structure flows are adequate. Without this calibration, the value of the model as a predictive tool is limited. More effort needs to be made to calibrate the model flows. Discharge data at structures, flow velocities and discharges at coastal creeks and rivers are available and could be used for this purpose.

Additional Comments:

By presenting proposed changes in the topography to the MRT, the topographic data set was improved and our confidence in this new data set was increased. We encourage the SFWMD to use both the MRT and Inter-agency Modeling Center to continue this open review of the model updates.

```
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c
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c
C---5----0----5----0----5----0----5----0----5----0----5----0----5----0--
      SUBROUTINE small_res_gw_flow(iresnum,ells_in_res,stage_res,
     +pond_in_res,prev_stage_res,aqperm_in_res,AQDEP_in_res,NCA_R)
C
csmb  passes data for permeability, current and previous stage and ponding,
csmb  and aquifer depth
csmb  Returns pond_in_res  (the predicted ponding depth in the reservoir)
C-----------------------------------------------------------------------
C
C     SCCS ID: %W% %G% SFWMD Planning Department
C       CVS Keywords
C       $Author: cwhite $
C       $Id: small_res_gw_flow.F,v 4.6 2001/09/10 15:36:40 cwhite Exp $
C       $Source: /vol/hsm/cvsroot/models/sfwmm/src/small_res_gw_flow.F,v $
C
C   PURPOSE:
C    SOLVE THE GROUNDWATER EQUATION
csmb  what dimension?  finite volume? finite difference? recharge? write the
csmb  equation
c
C
C   VARIABLE DEFINITIONS
C    AQDEP_in_res     THICKNESS OF AQUIFER BELOW MSL IN RESERVOIR (FT)
C    H          GROUNDWATER STAGE AT EACH NODE
C    IXM1       SUBSCRIPT OF NODE IN X-1 DIRECTION
C    IXP1           "     "    "     X+1     "
C    IYM1           "     "    "     Y-1     "
C    IYP1           "     "    "     Y+1     "
C    MAXXT      MAXIMUM NUMBER OF NODES IN ANY ROW
C    NCA        (1,2) INDICATOR TO CONTROL ALT. DIR. SOLUTION
C    aqperm_in_res     PERMEABILITY OF AQUIFER  IN RESERVOIR
C    TX ,TY     HARMONIC MEANS OF TRANSMISSIVITY
C-----------------------------------------------------------------------
C
      include 'stas.inc'
      include 'resadj.inc'
      include 'stat.inc'
      include 'budg.inc'
```

```
      dimension ells_in_res(2000,3),pond_in_res(2000,3)
     +  ,stage_res(2000,3),prev_stage_res(2000,3)
     +  ,aqperm_in_res(2000,3),AQDEP_in_res(2000,3)
c
       NCA_R = NCA_R + 1
       IF (NCA_R .GT. 2) NCA_R = 1
       IF (NCA_R .EQ. 1) THEN
         JJ = 1
         KK = NNODES(iresnum)-1
         INCR = 1
       ELSE
         JJ = NNODES(iresnum)
         KK = 2
         INCR = -1
       ENDIF
       DO IN = JJ,KK,INCR
c  reservoir cell loop
c     smb (does what)? assigns sign of groundwater flow term? determine
length?
c
          IF (NCA_R .EQ. 1 ) THEN
            INEXT = IN + 1
          ELSE
            INEXT = IN - 1
          ENDIF
          IF (idirect(iresnum,in) .eq. 1) THEN
            RLGTH_FLW = DX
             IF (node_reserv(iresnum,inext) .gt.
     +       node_reserv(iresnum,in)) THEN
               signr = 1.0
               noder = node_reserv(iresnum,in)
             ELSE
               signr = -1.0
               noder = node_reserv(iresnum,inext)
             ENDIF
          ELSE
            RLGTH_FLW = DY
             IF (node_reserv(iresnum,inext) .lt.
     +       node_reserv(iresnum,in)) THEN
               signr = 1.0
               noder = node_reserv(iresnum,in)
             ELSE
               signr = -1.0
               noder = node_reserv(iresnum,inext)
             ENDIF
          ENDIF
          WDTHGW = width_of_res(iresnum)*5280.
C
          DO ir1 = 1,noresincell(node_reserv(iresnum,in))
            IF (iresnum .eq. ires_index_in_cell
     +      (node_reserv(iresnum,in),ir1)) THEN
              iru = ir1
              GO TO 10
            ENDIF
          ENDDO
 10       DO ir2 = 1,noresincell(node_reserv(iresnum,inext))
            IF (iresnum .eq. ires_index_in_cell
```

```
     +      (node_reserv(iresnum,inext),ir2)) THEN
              ird = ir2
              GO TO 20
            ENDIF
          ENDDO
C--5----0----5----0----5----0----5----0----5----0----5----0----5----0--
C-----------------
C  FIRST FIND CURRENT TRANSMISSIVITY VALUES FOR THESE GRID POINTS
C  ALONG RESERVOIR
C-----------------
 20       NODE = node_reserv(iresnum,in)
          NODED = node_reserv(iresnum,inext)
          TH = aqperm_in_res(NODE,iru)*(AQDEP_in_res(NODE,iru)
     +    +stage_res(node,iru))
csmb
csmb  stage added to (k*H) as part of transmissivity???
          YP = aqperm_in_res(NODED,ird)*(AQDEP_in_res(NODED,ird)
     +    + stage_res(noded,ird))
          TYPAV = (TH + YP) / 2.0
          HAVG = (stage_res(NODE,iru)+prev_stage_res(NODE,iru)) / 2.0
          HDYP1 = HAVG - stage_res(NODED,ird)
C-----------------
C  NOW CALCULATE VOLUME OF GW FLOW ACROSS CELL BOUNDARY FACE
C-----------------
          HMVOL(NODER,idirect(iresnum,in))=HMVOL(NODER,idirect(iresnum
     +    ,in)) + signr*HDYP1*TYPAV*width_of_res(iresnum)*5280.* DT
     +    / RLGTH_FLW
          HMVOL_dailyr = HDYP1 * TYPAV * width_of_res(iresnum)
     +    *5280. * DT / RLGTH_FLW
c
c  adjust upstream and downstream reserv stages
c
          depth_to_wtu = amax1(ells_in_res(node,iru)
     +    - stage_res(node,iru),0.0) * s(node)
          depth_to_wtd = amax1(ells_in_res(noded,ird)
     +    - stage_res(noded,ird),0.0) * s(noded)
          dpth_of_gwflo = HMVOL_dailyr/(WDTHGW * RLGTH_FLW)
c         print *,dpth_of_gwflo,HMVOL_dailyr,WDTHGW,HAVG
c    +       ,RLGTH_FLW,stage_res(node,iru),stage_res(noded,ird)
c    +       ,'   GWGWGWGWGW'
          IF (HMVOL_dailyr .gt. 0.00001) THEN
             stage_res(node,iru) = stage_res(node,iru)
     +       - amin1(dpth_of_gwflo,pond_in_res(node,iru))
     +       - amax1(dpth_of_gwflo-pond_in_res(node,iru),0.0)
     +       / s(node)
             pond_in_res(node,iru) = pond_in_res(node,iru)
     +       - amin1(dpth_of_gwflo,pond_in_res(node,iru))
             stage_res(noded,ird) = stage_res(noded,ird)
     +       + amin1(dpth_of_gwflo,depth_to_wtd)/s(noded)
     +       + amax1(dpth_of_gwflo-depth_to_wtd,0.0)
             pond_in_res(noded,ird) = amax1(stage_res(noded,ird)
     +       - ells_in_res(noded,ird),0.0)
          ELSE
             sgn = -1.0
             stage_res(node,iru) = stage_res(node,iru)
     +       + amin1(sgn*dpth_of_gwflo,depth_to_wtu)/s(node)
     +       + amax1(sgn*dpth_of_gwflo-depth_to_wtu,0.0)
```

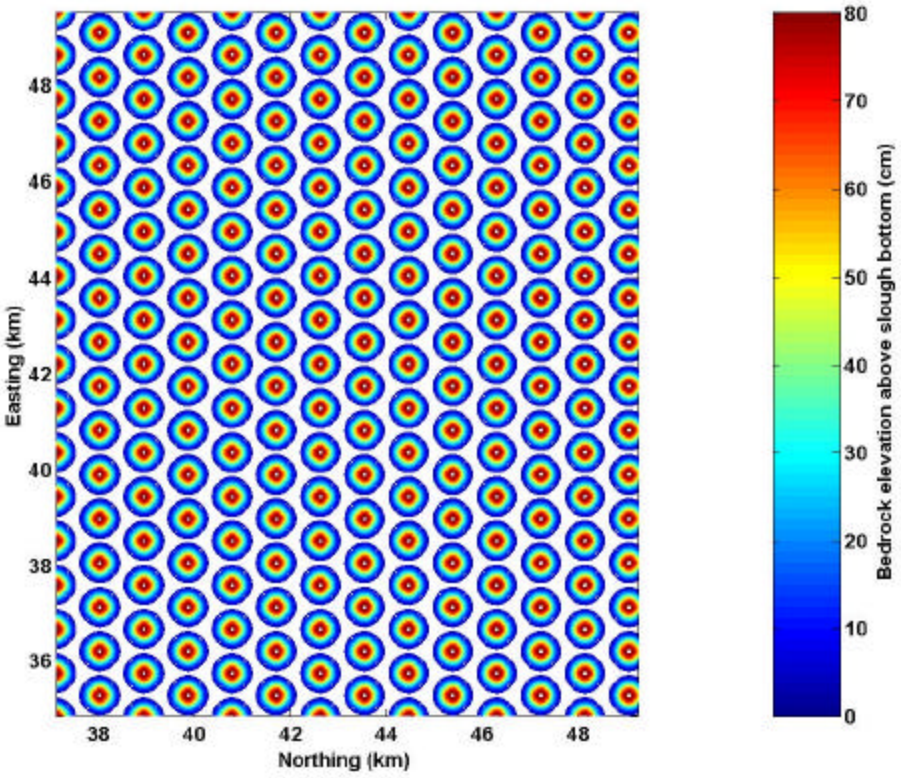
```
              pond_in_res(node,iru) = amax1(stage_res(node,iru)
     +        - ells_in_res(node,iru),0.0)
              stage_res(noded,ird) = stage_res(noded,ird)
     +        - amin1(sgn*dpth_of_gwflo,pond_in_res(noded,ird))
     +        - amax1(sgn*dpth_of_gwflo-pond_in_res(noded,ird),0.0)
     +        / s(noded)
              pond_in_res(noded,ird) = pond_in_res(noded,ird)
     +        - amin1(pond_in_res(noded,ird),sgn*dpth_of_gwflo)
            ENDIF
c
c  end of reservoir loop
        ENDDO
        RETURN
        END
```

Appendix B (more details available upon request)

Model Layout

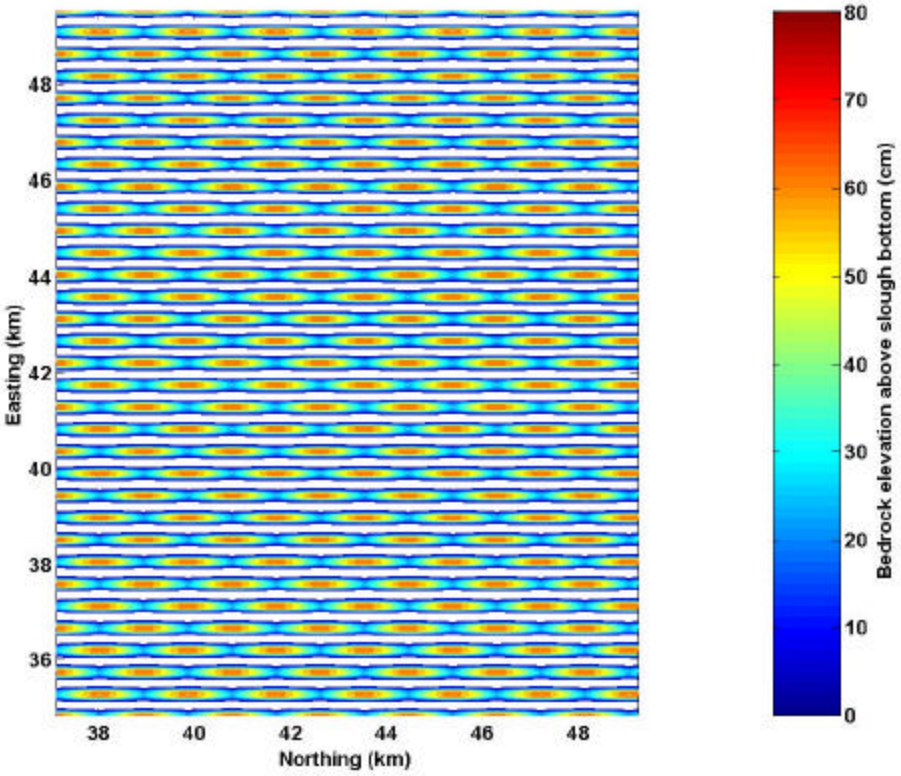
L-31N head specified

L-29
Head Specified



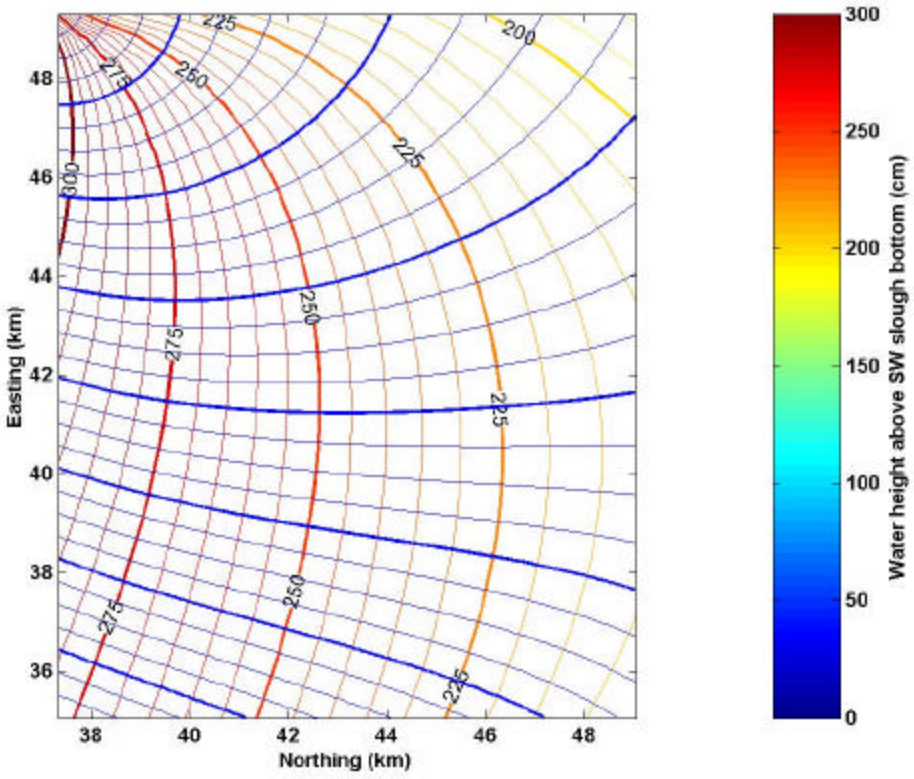
Anisotropic Resistance

Anisotropy =1 Modified Ridge and Slough

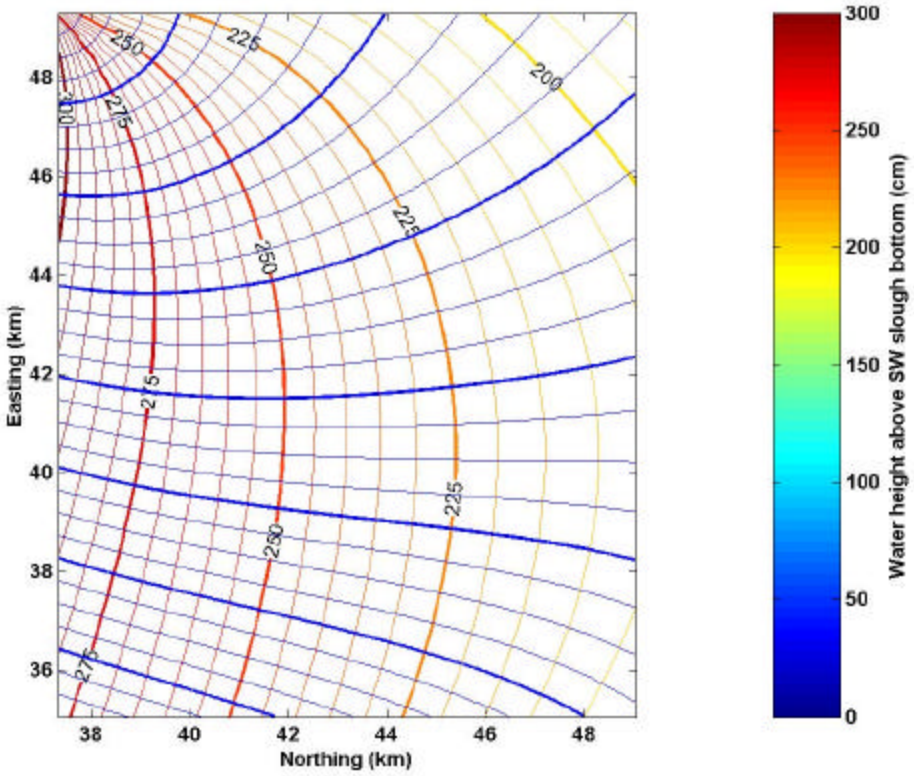


Anisotropic resistance
Anisotropy =16 Linear Ridge and Slough

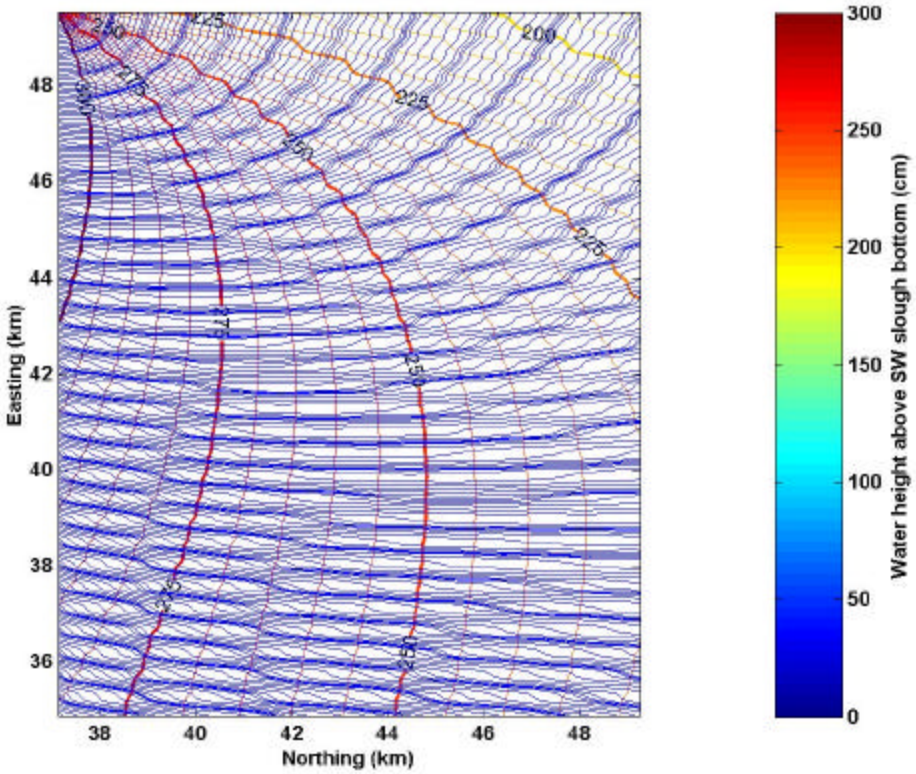
Model Results



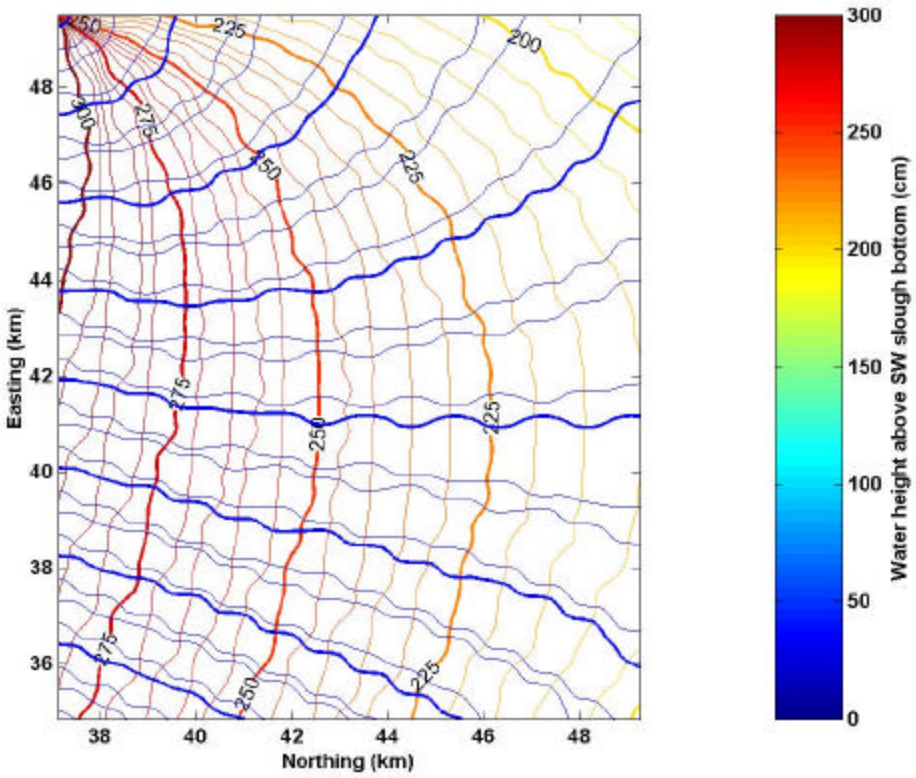
Isotropic resistance
drag coefficient multiplier =1



Isotropic resistance
drag coefficient multiplier= 4
In this model, increasing drag multiplier by 4 is like doubling Mannings n
Increasing resistance has minor effect on flow direction

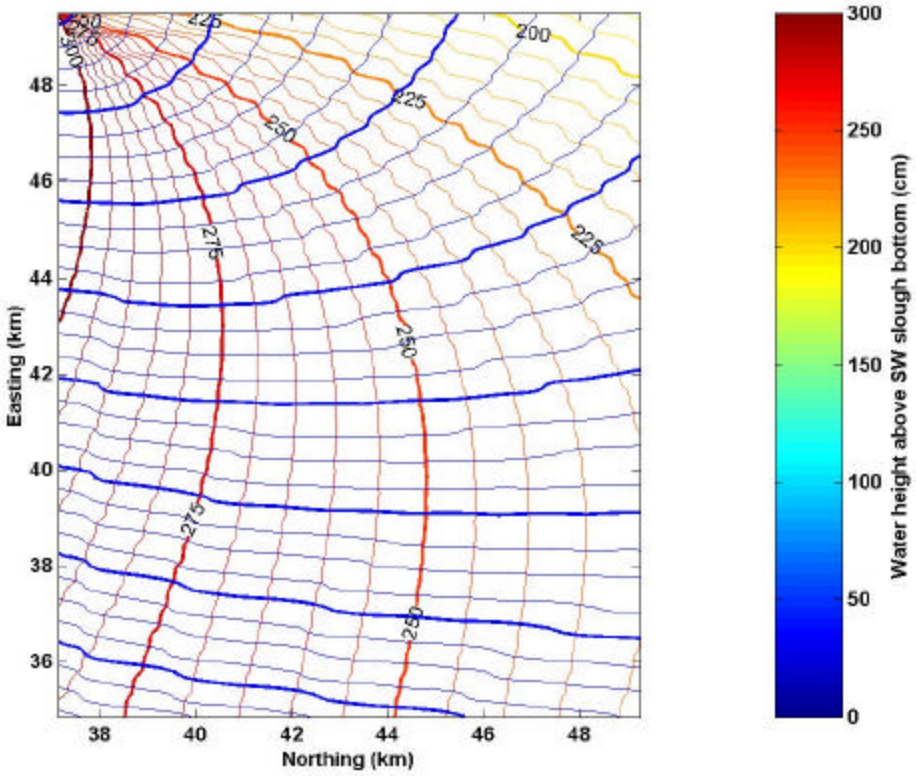


Anisotropy =1 Modified Ridge and Slough(detailed flow lines)



Anisotr

opy =1 Modified Ridge and Slough
Flow directions and contours vary slightly from isotropic case



Anisotropy = 16 Linear Ridge and Slough
Flow directions tend towards direction of Anisotropy
Effect on flow is more pronounced on Eastern Boundary due to more overland flow